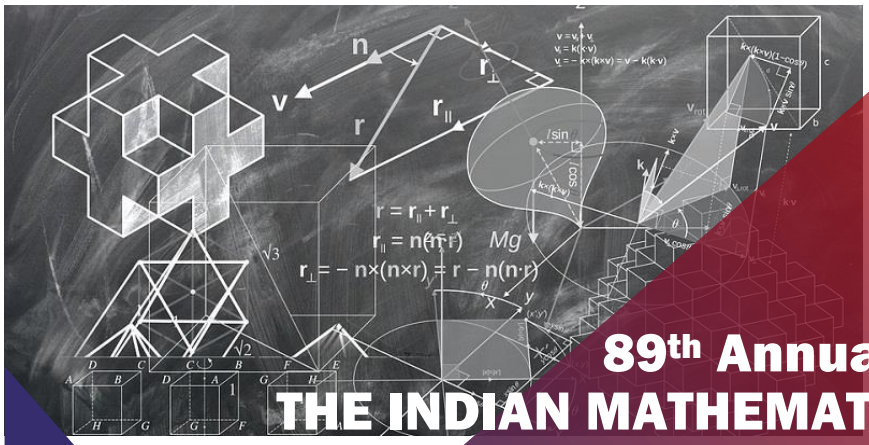

89th Annual Conference of THE INDIAN MATHEMATICAL SOCIETY

AN INTERNATIONAL MEET

DECEMBER 22-25, 2023

IMS
INDIAN MATHEMATICAL SOCIETY

IMS 2023

ABSTRACT BOOKLET

Highlights

Plenary talks

- Manjul Bhargava,
  Princeton University, USA.
- Helen M. Byrne,
  University of Oxford, UK.

Memorial Award Lectures

Invited talks

Symposia on

- Controllability & Differential Equations.
- Recent Trends in Graph Theory.
- Theoretical Astrophysics & Cosmology.
- Commutative Algebra.
- Hyperbolic PDEs and Shock waves.
- Harmonic Analysis.

Contributed Paper Presentations

Poster Presentations

BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI
ज्ञानं परमं बलम्

DEPARTMENT OF MATHEMATICS
BITS – PILANI, HYDERABAD CAMPUS

I am happy to note that Birla Institute of Technology and Science (BITS) Pilani, Hyderabad Campus, is hosting the 89th annual conference of the Indian Mathematical Society. Conducting the annual conference is one of the major activity of the society, besides running a Journal and a Newsletter.

The Academic Secretary Professor Raja Sekhar and the local organizing committee, in particular, Professor P. K. Sahoo deserve our appreciation for the meticulous planning of the conference. I wish the conference a grand success.

R. Balasubramanian
President, Indian Mathematical Society

It is a pleasure that the 89th Annual Conference of the Indian Mathematical Society- An International Meet is being organized at Birla Institute of Technology & Science-Pilani, Hyderabad Campus, Hyderabad during December 22-25, 2023 under the auspices of the Indian Mathematical Society IMS). It is a remarkable thing that the Conference opens on the 22nd December, the National Mathematics Day and the Birthday of legendry mathematician Srinivasa Ramanujan.

Although the conference takes place during these four days, the preparations of the conference started with the meeting of the Academic planning Committee (APC) of the IMS which took place in May 2023 at Pune. The APC planned an excellent academic program for the conference. The conference provides an effective platform to teachers, Students, and researchers of mathematics to exchange ideas and present their resaerches in the conferece. The participants of the conference will have a great experience of listening to eminent mathematicians and research scholars. I hope the deliberations of the conference will help participants to keep abreast of the latest developments in various areas of mathematics.

To encourage Students of mathematics and to appreciate good research work in mathematics, the Indian Mathematical Society instituted a few prizes and awards. The prizes and the awards for the year 2023 will be presented to the winners during the inaugural function of the conference. Indeed, presenting the prizes and awards to the winners would be memorable event in the function.

I should mention that this conference has attracted a large number of participants. The organizing institute is one of the best teaching and learning centers in the country. The Local Organizing Secretary and his team is working very hard to make this conference a great success.

On behalf of the IMS, I extend my warm greetings to all the delegates, speakers, and participants of the conference. I also wish all of them a very fruitful conference and memorable stay in the wonderful city of Hyderabad.

Welcome to the Annual of Conference of the IMS-An International Meet 2023 in Hyderabad!

M. M. Shikare
General Secretary, Indian Mathematical Society

I am very happy that the 89th Annual Conference of Indian Mathematical Society (IMS) - An International Meet is organized at the Birla Institute of Technology & Science-Pilani, Hyderabad Campus during 22 – 25 December 2023. The Academic Planning Committee, IMS has drawn a rich academic programme for this annual conference. Apart from various Memorial talks and Invited talks, six symposia will be organized on the themes:
Commutative Algebra, Controllability and Differential Equations, Harmonic Analysis, Hyperbolic PDEs and Shock Waves, Recent Trends in Graph Theory, Theoretical Astrophysics & Cosmology.

There has been an extraordinary response for the conference and we have received 248 research papers for contributory presentations and another 6 for various Prizes. There are few poster presentations to encourage young talent. This sets a record and increases the responsibility on us. Such a great response reflects the spirit "Mathematics for everyone-Mathematics everywhere" when the world is talking about AI & ML. I am sure that this conference will be fruitful to all the participants and will be a good platform for young researchers to interact with experts. My sincere appeal to all the participants is to induct more and more young mathematicians into the IMS and strengthen the activities of the society.

Wishing the very best to the organizers for the success of the conference.

G P Raja Sekhar, FNASc.

Academic Secretary, Indian Mathematics Society

Professor, Department of Mathematics

Indian Institute of Technology Kharagpur, Kharagpur 721302, India

Birla Institute of Technology and Science, Pilani
Pilani | Dubai | Goa | Hyderabad I Mumbai

Prof V Ramgopal Rao, Ph.D.,
Fellow of IEEE, TWAS, INAE, INSA, IASc, NASI
Former Director (2016-2021), IIT Delhi
J. C. Bose National Fellow
Vice-Chancellor & Senior Professor

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I am happy to note that the upcoming IMS Conference at BITS-Pilani, Hyderabad, will bring together mathematicians nationwide to share ideas and insights. While the foundational aspects of mathematics endure, the field continually evolves, drawing inspiration from diverse domains like computer science. Over the past decades, the intersection of computer science with mathematical realms such as number theory, topology, geometry, and statistics has proven invaluable. Notably, the surge in machine learning has added a distinctive statistical dimension to the mathematical landscape, creating a vibrant area of exploration. The dynamism of mathematics attracts bright minds, ensuring its perpetual vitality. May this conference foster the cross-pollination of ideas and ignite inspiration among the nation's youth.

I extend a very warm welcome to all the delegates and wish the event a grand success.

Sincerely,

Ramgopal Rao

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Birla Institute of Technology & Science, Pilani
Hyderabad Campus

G. Sundar, Ph.D.
Sr. Professor & Director

I am delighted to know that the Department of Mathematics at BITS Pilani Hyderabad Campus is hosting the "89th Annual Conference of the Indian Mathematical Society: An International Meet (IMS2023)" from December 22 – 25, 2023. On behalf of the Institute, I extend a warm welcome to the esteemed delegates, invited speakers, and attendees. I express my sincere gratitude to the Indian Mathematical Society for entrusting BITS Pilani Hyderabad Campus with the responsibility of organizing this prestigious event, and thereby recognizing the growing and exceptional capabilities of our faculty and students.

I extend my best wishes for the grand success of the Conference.

(G. Sundar)

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Birla Institute of Technology & Science, Pilani
Hyderabad Campus
Prof. Pradyumn Kumar Sahoo, Ph.D.

We are delighted and privileged to organize the 89th Annual Conference of the Indian Mathematical Society from December 22 - 25, 2023 at the Department of Mathematics, Birla Institute of Technology and Science-Pilani, Hyderabad Campus. The Indian Mathematical Society (IMS) is the oldest Mathematical Society in the country. The purpose of the conference is to stay updated on the most recent advancements in the field of Mathematics and to foster meaningful interdisciplinary collaboration while maintaining the integrity of the major disciplines. We are fortunate to have distinguished speakers sharing their enormous ocean of expertise and critical knowledge with us. It will benefit all of us through discussions and collaborations with globally renowned experts.

The Department of Mathematics at BITS-Pilani, Hyderabad was founded in 2008 and provides programs for undergraduate, postgraduate, and Ph.D. degrees. The department has 28 faculty members, of whom 3 are Professors, 10 are Associate Professors, and 15 are Assistant Professors. They have a commendable research track record and have undertaken research projects that have received funding from different government bodies, such as NBHM, UGC, DST SERB, CSIR, and others. Currently, the department offers Integrated M.Sc. and Ph.D. in Mathematics. We also offer various courses and programs to Industry professionals through Work Integrated Learning Programs. The department of Mathematics has at present 69 Ph.D. students.

I am grateful to Prof. V. Ramgopal Rao, Vice-Chancellor; Prof. G. Sundar, Director; Prof. P Yogeeswari, Dean, the conveners and the members of the Department of Mathematics for their extensive support. I express my warm greetings to all the speakers and participants of the conference during these four days and wish them good luck in their furture endeavors. I extend my best wishes to the conference organizers for a successful and smooth event management. I am sure that the conduct of IMS 2023 would provide all delegates with remarkable interaction and ideas.

(P.K. Sahoo)
Head, Department of Mathematics
BITS-Pilani, Hyderabad Campus

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Message from the Conveners



It is our great honor and privilege to welcome all the delegates to the 89th Annual Conference of the Indian Mathematical Society (IMS 2023).

The entire organizing team and our colleagues at BITS-Pilani, Hyderabad Campus together with the office bearers of the IMS have done a commendable job to make the necessary arrangements for a comfortable stay for the delegates. We are sure that all of you will be celebrating the conference days, i.e., 22-25th December, 2023 as an academic festival. We hope that the participants would fruitfully utilize their visit, interact and exchange ideas.

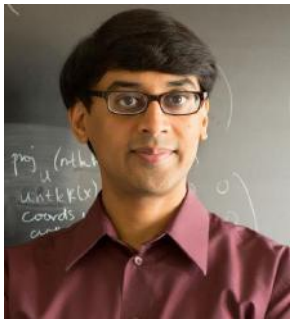
IMS is one of the major platform where attention is drawn from various sectors. The need of the day is to make significant interdisciplinary collaboration without diluting the core fields. This is a big challenge. We are confident that this conference would help many younger colleagues and students to take a big step in this direction.

It is a matter of great privilege for the Department of Mathematics, BITS-Pilani, Hyderabad Campus, to organize this event for the first time in the history of BITS-Pilani. We take this opportunity to thank the sponsors of IMS 2023, NBHM, SERB and the BITS-Pilani. We thank our Honorable Vice-Chancellor Prof. V. Ramgopal Rao, Director of BITS-Pilani, Hyderabad Campus Prof. G. Sundar, Dean Administration, Prof. P. Yogeeswari, Head of Dept. of Mathematics Prof. P.K. Sahoo, and all other faculty members, research scholars, and students for their invaluable support. We thank the renowned mathematicians and colleagues across the country and abroad for attending the conference and presenting their valuable works. It is because of the continuous support of all of you that this event has come to this day.

It is indeed our privilege to have you all at BITS-Pilani, Hyderabad Campus. We wish you all a pleasant stay and happy memories of the conference.

Prof. Sumit K Vishwakarma	Prof. Santanu Koley	Dr. P Sajith
Convener IMS 2023	Convener IMS 2023	Convener IMS 2023

Plenary Lecture



Prof. Manjul Bhargava is currently a Professor of mathematics at Princeton University and also a Stieltjes Professor of number theory at Leiden University. Prof. Bhargava received his AB from Harvard University with summa cum laude in Mathematics in 1996. He completed his doctoral studies at Princeton University under Prof. Andrew Wiles in 2001 with a Hertz Fellowship.

He was a visiting scholar at the Institute of Advanced Studies and Harvard University before joining Princeton University as a tenured Full Professor in 2003. He also holds adjunct professorship positions at TIFR, IIT Bombay, University of Hyderabad.

Prof. Bhargava has made fundamental contributions to number theory including the generalization of Gauss's binary quadratic forms, the generalized definition of factorial, and proving Polya's conjecture. He has given the proof of so-called Conway's 15 theorem and 290 theorem. He has also opened the new pathways in the elliptic curve in number theory by proving that the average rank of all elliptic curves over Q is bounded and most hyperelliptic curves over Q have no rational points.

Prof. Bhargava has won many prizes and awards in his life including the Fields medal in 2014 which is recognized as one of the highest honor among mathematicians. He has also received Padma Bhushan, the third-highest civilian award of India. He has also received the Clay Research Award, the SASTRA Ramanujan Prize, the Cole Prize, Infosys Prize, Fermat Prize. He has also been elected to some of the most prestigious academic societies in the world like Fellow of the Royal Society, National Academy of Science, and American Academy of Arts and Science.

Plenary Lecture

Prof. Helen Mary Byrne is currently a professor of mathematical biology at Oxford University. After completing her undergraduate studies in mathematics at Newnham College, Cambridge, she did her graduate studies in Mathematical Modelling and Numerical Analysis at the University of Oxford. Later, she did PhD from the same university under the supervision of Prof. John Norbury. She did her post-doctorate studies at Hammersmith Hospital's cyclotron unit and at the University of Bath in mathematical biology.

She joined as a lecturer at the University of Manchester Institute of Science and Technology in 1996, and soon after she joined the University of Nottingham, where she became a full professor in 2003. In 2011 she joined as a professor in mathematical biology at the University Of Oxford.

Prof. Byrne is a leading figure in the mathematical models of tumor growth and angiogenesis formation. Her work has been published in some of the world's leading journals including Nature Communications and Nature Reviews Cancer etc. to name a few.

She has been awarded various prizes some notable ones are the Leah Edelstein-Keshet Prize in 2018 from the Society for Mathematical Biology. She also has been awarded Fellow of the Society for Mathematical Biology in 2021. She has also served as director of the Mathematical, Physical, and Life Sciences (MPLS) Division at the University of Oxford from 2016 to 2020.

Hansraj Gupta Memorial Award Lecture

Anandavardhanan obtained his Ph.D. in Mathematics from the University of Hyderabad in 2003. During 2003-2005, he was a Visiting Fellow at TIFR Mumbai. He has been on the faculty in IIT Bombay from July 2005 onwards. He works in the areas of Automorphic Forms and Representation Theory.

P.L. Bhatnagar Memorial Award Lecture

Nandakumaran is currently the Chair of the Department of Mathematics, Indian Institute of Science, Bangalore. He has done his Ph D in TIFR (TIFR-IISc), Bangalore in the area of partial differential equations. He works in the asymptotic analysis of PDE operators (known as homogenization) and control problems, guided many students and has a large number of publications in top class journals. He has two post graduate/PhD level co-authored books on “Ordinary differential equations: Principles and Applications” and “Partial differential Equations: Classical Theory with a Modern Touch” published by Cambridge. He is also awarded Sir C. V. Raman Young Scientist Karnataka State Award for Mathematics in 2003 and is Fellow of the National Academy of Sciences, India (NASI). He was also the National Convener of one of the flagship fellowship program Kishore Vigyanik Prothsahan Yojana (KVPY) and he is in the Editorial boards of few journals.

Ganesh Prasad Memorial Award Lecture

B V Rathish Kumar did his PhD from Sri Sathya Sai Institute of Higher Learning, Prasanthinilayam, AP, India. He is currently professor at Department of Mathematics & Statistics, IIT Kanpur. His research interests include Finite Element Analysis, Computation & Application, Parallel Numerical Methods, Image Processing, Computational Biomechanics, Numerical Analysis and Computational Fluid Dynamics.

Srinivasa Ramanujan Memorial Award Lecture

Nagaraj D S obtained his M.Sc.(Mathematics) degree from University of Mysore and PhD. Degree from Tata Institute of Fundamental Research (TIFR) Mumbai. He was faculty at the Institute of Mathematical Sciences, Chennai from 1993 to 2018. He was a faculty at IISER Tirupati from 2018 till Aug 2023. Currently he is a visitor at IISER Tirupati.

Nagaraj D S did research is in Algebraic Geometry. He was also interested in Algebraic Number Theory. He is a fellow of Indian Academy of Sciences Bangalore, The National Academy of Sciences, Allahabad and Indian National Science Academy, Delhi.

V Ramaswami Aiyar Memorial Award Lecture

Jaya Iyer had her education (BSc, MSc) in Mumbai. She then enrolled at the University of Mumbai to obtain her PhD in mathematics and worked with Professor S. Ramanan at the Tata Institute, Mumbai in Algebraic Geometry. She did postdoctoral studies at the University of Paris, University of Essen, Max-Planck Institute, Bonn (1999-2003), and spent a year at IAS, Princeton (2006-07). She is with the Institute for Mathematical Sciences, Chennai since 2003. Her current research interests are in Algebraic cycles, Moduli spaces and the Chern-Simons theory. She is a Fellow of Indian Academy of Sciences, Bengaluru, and National Academy of Sciences, Allahabad.

Schedule	
Time	*Event*
December 22, 2023	
8:30 - 9:25	**Registration**
9:30 - 10:30	**Inauguration**
10:35 - 10:55	HIGH TEA
11:00 - 12:00	**Presidential Address** (Technical): R Balasubramanian, Institute of Mathematical Sciences, Chennai *Product of three primes in arithmetic progression*
12:00 - 13:00	**P1: Plenary Lecture:** Manjul Bhargava, Princeton University, USA *Integers expressible as the sum of two rational cubes*
13:00 - 14:10	LUNCH
14:10 - 15:10	**M1: Hansraj Gupta Memorial Award Lecture:** U K Anandvardhanan, IIT Bombay *"Distinguished representations"*
15:10 - 15:40	**In parallel sessions (Each talk: 30 minutes)**
	A1: P K Jain Awardee Lecture: Priyanka Grover, Shiv Nadar University, Delhi *"Subdifferential set of the joint numerical radius of a tuple of matrices"*
	A2: J B Shukla Awardee Lecture Tanuja Das, University of New Brunswick, Canada *"Effect of a novel generalized incidence rate function in SIR model: Stability switches and bifurcations"*
15:40 - 15:55	TEA-BREAK
16:00 - 17:00	**Invited lectures in parallel sessions (Each talk: 30 minutes)**
	Track -1: (T1-1) A M Mathai, Emeritus Professor, McGill University, Canada *"Some Matrix-variate Models Applicable in different areas"* (T1-2) Anshumali Srivastava, Rice University, USA *"Statistical Estimations from Locality Sensitive Hashing (LSH): Adaptive Sampling at the cost of random sampling"*
	Track -2: (T2-1) R. Radha, Department of Mathematics, Indian Institute of Technology Madras, Chennai *"Special affine Fourier transform"* (T2-2) R Thangadurai, Harish-Chandra Research Institute, Prayagraj *"Trace of powers of algebraic numbers"*

Time	*Event*
17:00 - 17:45	**Paper presentations for Prize Category in parallel sessions (Each talk: 15 minutes)**
	Panel-1 **Group - 1** (Discrete Mathematics (Combinatorics, Graph Theory, Posets), Lattice Theory, Set Theory, Logic, Number Theory and related areas): Arun J. Manattu, Cochin University of Science and Technology, Kerala *"An Edge Labeling Problem of Graphs"* Amit S. Wadile, Dahiwadi College Dahiwadi, Satara *"Characterization for connectedness of essential element graph of a lattice"*
	Panel-2 **V M Shah Prize:** Yogeshkumar K. Patel, Government Science College, Pardi, Gujarat *"Approximation of conjugate Fourier series for function in generalized Holder class by $K\lambda$ means"* **Group - 4** (Differential / Integral / Functional equations and inequalities, Special Functions, Numerical Analysis and related areas): Suma P.B., Manipal Institute of Technology, Manipal *"Approximation of nonlinear ill-posed equations in Hilbert space using Traub-like methods"*
	Panel-3 **Group - 5** (Solid Mechanics, Fluid Mechanics, Electromagnetic Theory, Magneto-Hydrodynamics, Astronomy, Astrophysics, Relativity and related areas): Kavya N S, Kuvempu University, Shankaraghatta *"Gaussian noncommutative wormhole solutions in f(Q,T) gravity with conformal symmetry"* **Group - 6** (Operations Research, Optimization, Computational Mathematics, Information Technology, Bio mathematics, History of Mathematics and related areas): Sonu Lamba, Indian Institute of Technology Patna *"Eyes on the Prize: Modeling Isolation and Hygiene Compliance for Taming the Direct and Indirect Transmission of Conjunctivitis"*
17:45 - 19:15	**Contributory Paper presentations: CP1**
IMS Subject	A1 to A10 (A6 Withdrawn)
	F1 to F9 (F6 Withdrawn)
	C1 to C9 (C1,C6 Withdrawn)
	H1 to H9 (H8 Withdrawn)
	I 1 to I 12 (I2, I3, I6 Withdrawn)
	H 17 to H27 (H21, H23 Withdrawn)
20:00	DINNER

Time	*Event*
December 23, 2023	
9:00 - 10:00	**M2: P.L. Bhatnagar Memorial Award Lecture:** A. K. Nandakumaran, Indian Institute of Science, Bangaluru *"Multi-scale Convergence in PDEs and Homogenization"*
10:00 - 10:20	TEA-BREAK
10:20 - 12:50	**Symposium in Parallel sessions**
	(S1): Hyperbolic PDEs and Shock Waves Convenor: Tungala Raja Sekhar, IIT Kharagpur **Speakers:** (S1-1) Manas Ranjan Sahoo, National Institute of Science Education and Research, Bhubaneswar *"Initial boundary value problem for 1D scalar balance laws with strictly convex flux"* (S1-2) Triveni Prasad Shukla, National Institute of Technology, Warangal *"Interaction of shock waves in a conservation law without convexity"* (S1-3) Purnima Satapathy, Visvesvaraya National Institute of Technology, Nagpur *"Insight into symmetries and their applications to Partial Differential Equations"* (S1-1-4) Minhajul, BITS Pilani K K Birla Goa Campus *"Interaction of shocks in drift-flux equations of two-phase flows"* (S1-5) Mohammad Zafar, National Institute of Technology, Jalandhar *"Delta Shocks and vacuum states in the Riemann solutions of Chaplygin Euler equations as pressure and magnetic field drop to zero"* (S1-6) T Raja Sekhar, Indian Institute of Technology, Kharagpur *"Two-dimensional Riemann problem and wave interactions in a thin film model of a perfectly soluble antisurfactant solution"*
	(S2): Recent Trends in Graph Theory Convenor: Tarakeshwar Singh, BITS Pilani K K Birla Goa Campus **Speakers:** (S2-1) Mukti Acharya, Christ University Bangalore *"Product cordial and signed product cordial graphs"* (S2-2) Amitava Bhattacharya, Tata Institute of Fundamental Research, Mumbai *"Van der Waerden type results in Ramsey Theory "* (S2-3) Bhawani Sankar Panda, Indian Institute of Technology, Delhi *"Matching with preferences: Stable Matching and Beyond"* (S2-4) Suresh M Hegde, National Institute of Technology Karnataka, Surathkal *"A graph theoretic model for a generic three jug puzzle"* (S2-5) Tarakeshwar Singh, BITS Pilani K K Birla Goa Campus *"On Local Distance Antimagic Coloring of Graphs"*

Time	*Event*
12:50 - 14:00	LUNCH
14:00 - 15:00	**Contributory Paper presentations: CP2**
IMS Subject	E2 to E5
	B1 to B5 (B2 Withdrawn)
	I 18 to I 22
	H 10 to H 16 (H 11, H 12 Withdrawn)
	I 13 to I 17
	H 28 to H 32
15:00 - 16:00	**Invited lecture in Parallel sessions (Each talk: 30 minutes)**
	Track -1: (T1-3) Ch. Srinivasa Rao, Department of Mathematics, Indian Institute of Technology Madras, Chennai *"Large time asymptotics to solutions of some nonlinear partial differential equations"* (T1-4) Smita Bedekar, Interdisciplinary School of Scientific Computing, Savitribai Phule Pune University *"Scientific Computing through the lens of Cryptography"*
	Track -2: (T2-3) Anuradha Kameswari, Department of Mathematics, Andhra University *"Ring Based Encryption with Lucas Sequences"* (T2-4) Ganesh Kadu, Department of Mathematics, Savitribai Phule Pune University *"Reciprocal eigenvalue properties using the Mobius and Zeta functions on Boolean algebras"*
16:00 - 16:20	TEA-BREAK & Group Photo
16:20 - 17:20	**P2: Plenary Lecture:** Helen Byrne, Oxford University, UK *"Using mathematical modelling to understand how the microenvironment influence cell behaviours in cancer and atherosclerosis"*
17:20 - 19:00	**Contributory Paper Presentations: CP3**
IMS Subject	G1 to G9 (G2, G9 Withdrawn)
	B6 to B16 (B6, B8 Withdrawn)
	C10 to C17 (C 14 Withdrawn)
	E6 to E17
	H48 to H59 (H 51, H52, H53, H55, H57 Withdrawn)
	H33 to H40 (H 38 Withdrawn)
18.50 - 19.10	**Symposium talk** Aroonkumar Beesham, National Institute for Theoretical and Comp. Sciences, South Africa *"Some comments on dark energy"*
19:15 - 20:15	**Cultural Programme**
20:30 - 22:00	CONFERENCE DINNER

Time	*Event*
December 24, 2023	
9:00 - 10:00	**M3: Ganesh Prasad Memorial Award Lecture:** B. V. Rathish Kumar, Indian Institute of Technology Kanpur *"Variational Multiscale Stabilized Sub-Grid Finite Element Analysis for Fluid Flow with application in Health Care"*
10:00 - 10:30	**In parallel sessions**
	A5: B N Waphare Aawrdee Lecture: Vandana P. Bhamre, Pratap College, Maharashtra *"Covering energy of posets and its bounds"*
	A6: A. Narsinga Rao Award lecture: Shrivathsa Pandelu, University of Minnesota, USA *"Results on finite collection of polygons and a proof of the Jordan curve theorem"*
10:30 - 10:45	TEA-BREAK
10:45 - 11:45	**M4: Srinivasa Ramanujan Memorial Award Lecture:** D. S. Nagaraj, Indian Institute of Science Education and Research, Tirupati *"Rationality questions in algebraic geometry"*
11:45 - 13:05	**Contributory Paper Presentations: CP4**
IMS Subject	A11 to A18 (A12, A 15, A 16 Withdrawn)
	F10 to F16
	D1 to D7 (D1, D3, D7 Withdrawn)
	E18 to E25 (E 22 Withdrawn)
	I23 to I29
	H41 to H47
13:05 - 14:00	LUNCH
14:00 - 15:45	**Contributory Paper Presentations: CP5**
IMS Subject	G10 to G18 (G 10, G11, G13 Withdrawn)
	B17 to B26 (B 20, B 23 Withdrawn)
	D8 to D14 (D8 Withdrawn)
	H 60 to H 71 (H61 Withdrawn)
	E26 to E35 (E26 Withdrawn)
	I30 to I36
15:45 - 16:15	**In parallel sessions (Each talk: 30 minutes)**
	A3: A. K. Agarwal Awardee Lecture: Apoorva Khare, IISc Bengaluru *'Determinants with any smooth function reveal all Schur polynomials'*

Time	*Event*
	A4: Subhash Bhatt Awardee Lecture Projesh Nath Choudhury, IIT Gandhinagar *"Total positivity: characterizations and connections"*
16:15 - 16:30	TEA-BREAK
16:30 - 19:00	**Symposium in Parallel sessions**
	(S3): Controllability and Differential Equations Convenor: Muslim Malik, Indian Institute of Technology, Mandi **Speakers:** (S3-1) Enrique Zuazua, Friedrich-Alexander-Universität Erlangen-Nürnberg *"Control and Machine Learning"* (S3-2) Raju K George, Indian Institute of Space Science and Technology, *"Controllability of LTI Networked Systems"* (S3-3) Javid Ali, Aligarh Muslim University, Aligarh *"Controllability results for Hilfer fractional differential equations via measure of noncompactness"* (S3-4) Anurag Shukla, Rajkiya Engineering College, Kannauj *"Optimal control results for second order differential equations"* (S3-5) Muslim Malik, Indian Institute of Technology, Mandi *"Controllability of Singular Switched Differential Equations on Non-uniform Time Domain"*
	(S4): Theoretical Astrophysics and Cosmology Convenor: Farook Rahaman, Jadavpur University, Kolkata **Speakers:** (S4-1) Banibrata Mukhopadhyay, Indian Institute of Science, Bangalore *"Super-Chandrasekhar white dwarf, its mass-limit and consequences"* (S4-2) Anjan Ananda Sen, Jamia Millia Islamia, New Delhi *"Cosmological Tensions and Hints for New Physics"* (S4-4) M Sami, Centre for Cosmology and Science Popularization, SGT University, Gurugram *"Outstanding issues in modern cosmology"* (S4-5) Mehedi Kalam, Aliah University, Kolkata *"Wormhole and Galactic halo dark matter"* (S4-6) Farook Rahaman, Jadavpur University, Kolkata *"A Mathematical Framework for Transforming a Static Wormhole into a Rotating Wormhole"* (S4-7) Sudhir Kumar Srivastava, DDU Gorakhpur University, Gorakhpur *"Cosmological Concepts in Religious Text"*
20:00	DINNER

Time	*Event*
December 25, 2023	
8:30 - 9:30	**M5: V Ramaswami Aiyar Memorial Award Lecture:** Jaya Iyer, The Institute of Mathematical Sciences, Chennai *"Topological invariants of smooth manifolds"*
9:30 - 12:00	**Symposium in Parallel sessions**
	(S5): Commutative Algebra Convenor: Vijay Kodiyalam, The Institute of Mathematical Sciences, Chennai Speakers: (S5-1) Jugal Kishore Verma, Indian Institute of Technology, Bombay *"The Hilbert-Kunz multiplicity of powers of ideals"* (S5-2) Manoj Kummini, Chennai Mathematical Institute *"Polynomial invariant rings for finite p-groups"* (S5-3) Mrinal Kanti Das, Indian Statistical Institute, Kolkata *"Unimodular rows"* (S5-4) Mitra Koley, Indian Statistical Institute, Kolkata *"Singularities in Prime Characteristics"* (S5-5) Mohit Upmanyu, Tata Institute of Fundamental Research & CMI, Mumbai *"AmAC subset of power series ring and its applications"*
	(S6): Harmonic Analysis Convenor: Aparajita Dasgupta, Indian Institute of Technology, Delhi **Speakers:** (S6-1) Somnath Ghosh, Indian Institutes of Science, Bangalore *"Uncertainty principle for solutions of the Schrödinger equation"* (S6-2) Kalachand Suin, Seoul University, Seoul *"Bilinear maximal functions associated with degenerate surfaces"* (S6-3) Ramesh Manna, National Institute of Science Education and Research, Bhubaneswar *"Fixed time estimates for Hermite semigroup in Lebesgue and modulation spaces"* (S6-4) Lalit Mohan, Indian Institute of Technology, Delhi *"Multilinear Fourier Integral Operators on Modulation Spaces "* (S6-5) Vishvesh Mishra, Ghent University, Ghent, Belgium *"Boundedness of pseudo-differential operators on graded Lie groups"* (S6-6) D Venku Naidu, IIT Hyderabad *"Vertical operators on Bergman space over UHP"*
12:00 - 13:00	General Body Meeting to be followed by Valedictory Function
13:00	LUNCH

Contents

Plenary Talk

Integers expressible as the sum of two rational cubes

Manjul Bhargava
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Plenary Talk

Using mathematical modelling to understand how the microenvironment influence cell behaviours in cancer and atherosclerosis

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Cells experience multiple chemical and mechanical stimuli in their microenvironment which may alter their behaviour or phenotype. For example, following tissue injury, endothelial cells start to proliferate and bias their movement up spatial gradients of diffusible species in order to generate the new blood vessels needed to heal a wound. Equally, local levels of Wnt proteins drive phenotypic changes in the epithelial cells that line the intestinal crypt. In this talk, we will present two case studies which show how mathematical approaches can be used to describe cell responses to different environmental cues.

First, we develop a two-phase model for cell migration in response to interstitial flow. We formulate the model as a system of continuum equations for the spatio- temporal evolution of the cell volume fraction and flux, in response to forcing terms which depend on the local direction and magnitude of mechanochemical cues. As has been observed experimentally, the model predicts downstream- oriented, chemotactic migration at low cell volume fractions, and upstream- oriented, tensotactic migration at larger volume fractions. We show that the critical volume fraction, at which the system transitions from downstream to upstream migration, is dominated by the ratio of the rate of chemokine secretion and advection. Our model also predicts that upstream, tensotaxis-dominated migration may only occur at early times, and that downstream, chemotaxis-dominated migration persists at later times due to the dispersive effect of cell diffusion.

We will then introduce a lipid structured mathematical model to investigate the impact of low- and high-density lipoproteins on the distribution of lipid across macrophages within atherosclerotic lesions. Macrophages are the dominant immune cell type within such lesions and their ability to ingest and off-load lipid is strongly dependent on their lipid load. Using a combination of numerical and analytical methods, we show how the balance between low- and high-density lipids determines whether the macrophage distribution is skewed towards low levels (healthy state), high levels (pathological state) or unimodal (a transitional state).

Memorial Award Lectures

Hansraj Gupta Memorial Award Lecture

Distinguished representations

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In this talk we'll give a broad introduction to the topic of distinguished representations which are the central objects of study in the relative Langlands program. We'll motivate the question by first looking at finite groups and then introduce the corresponding notions for p-adic and adelic groups. We'll survey some of the results for GL(n) and then state a few recent results for SL(n).

P.L. Bhatnagar Memorial Award Lecture

Multi-scale Convergence in PDEs and Homogenization

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Abstract

In PDEs, quite often it becomes necessary to approximate the PDEs by a family of PDEs involving a parameter which may go to 0 or ∞. It can also happen the other way that the physical systems produces a family of PDEs and we may need to find the limiting PDE. It can be due to several reasons, for example due to the presence of multi-scales. Multi scales arise in many physical and industrial problems, and industrial constructions which lead to very complicated structures. Homogenization is a branch of science where one tries to understand the microscopic structures via a macroscopic medium by taking care of the various scales involved in the problem which appears through the solutions. But mathematically these solutions lie in an infinite dimensional space like Sobolev space. The standard procedure is to obtain a-priori estimates which only produce weak convergence which in turn averages out in the limit (hence disappears small scales) the interesting and relevant physical phenomena (information), namely the rapid oscillations and concentrations. So we need to understand the hidden, but lost oscillations (similarly concentrations) due to weak convergence which are essential to pass to the limit. There are several methods to study such problems developed in the last 50 years and a couple of recent, but powerful methods are *two-scale method* and *method of unfolding operators*. In the first part, we briefly introduce the theory of homogenization to address the general audience and later we discuss the problems which we are dealing with, for the last 12-15 years by our group.

Ganesh Prasad Memorial Award Lecture

Variational Multiscale Stabilized Sub-Grid Finite Element Analysis for Fluid Flow with application in Health Care

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In this talk, we will take a tour on the application of concepts from mathematics in the development of a stable and robust computational approach to solve few problems from real life. To begin with, I will introduce the concept of variational multiscale Sub-Grid Finite Element Method (VMSSGFEM) for differential equations. The notion of apriori and aposteriori error analysis of the method in the context of transport PDE models will be discussed. Further, the notion of stabilized VMSGFEM for transport equations, which is especially helpful to handle convection dominated fluid flows of scientific and engineering interest will be dealt with. Then an extension of the same to the unified Brinkman-Stokes/Transport Model and NS Model will be presented. Finally, the application of the method for computing hemo-dynamics in complex arterial geometries will be briefly touched upon to open up a couple of problems to math world from health care.

Srinivasa Ramanujan Memorial Award Lecture

Rationality questions in algebraic geometry

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In algebraic geometry classification of algebraic varieties is a fundamental problem. Among them rational varieties are an important class of varieties. In this lecture we introduce all the basic concepts that are required to understand the rationality questions in algebraic geometry and give examples of rational and non rational varieties.

V Ramaswami Aiyar Memorial Award Lecture

Topological invariants of smooth manifolds

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In this talk, we will discuss topological invariants of a smooth manifold X which lie in the graded singular cohomology of X. We will explain vector bundles, connections and construction of their higher order invariants.

IMS Award Lectures

P K Jain Award Lecture

Subdifferential set of the joint numerical radius of a tuple of matrices

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Approximation problems in normed spaces has been a significant centre of interest for many years. It is very much related to the Birkhoff-James orthogonality in normed spaces. An important tool in dealing with these problems is the subdifferential set of the respective norm function. In this talk, an expression for the subdifferential set of the numerical radius of matrices is obtained. Further extensions to the joint numerical radius of a tuple of matrices shall be discussed. Its applications to the Birkhoff-James orthogonality in the space consisting of tuples of matrices equipped with the joint numerical radius norm shall be discussed.

J B Shukla Award Lecture

Effect of a novel generalized incidence rate function in SIR model: Stability switches and bifurcations

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In a disease outbreak, the incidence rate might fluctuate, rising or dropping with increasing infections during various phases of disease spread. This presentation will delve into the consequences of these nonmonotonic changes in the incidence rate on the stability of endemic equilibria in an SIR disease model, as presented in the article ""Das, T., & Srivastava, P. K. (2023). Effect of a novel generalized incidence rate function in SIR model: Stability switches and bifurcations. Chaos, Solitons & Fractals, 166, 112967."" It is found that when the incidence rate function is increasing at an anti-saddle endemic equilibrium, the equilibrium may become either stable, unstable or switch stability via a system parameter change. Further, when the incidence rate function is non-monotonic and if the incidence rate decreases at an anti-saddle endemic equilibrium, the equilibrium is always stable. However, this stable endemic equilibrium may switch its stability once or multiple times and finally becomes unstable if incubation delay is present in the system. We established backward bifurcation, forward (transcritical) bifurcation, Hopf bifurcation and saddle–node bifurcation and Hopf-Hopf bifurcation in this study.

A. K. Agarwal Award Lecture

Determinants with any smooth function reveal all Schur polynomials

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Let $n = 2$, and u_1, u_2 and v_1, v_2 be real scalars. Given a smooth function $f : \mathbb{R} \to \mathbb{R}$, what are the derivatives of the 2×2 determinant

$$\Delta_f : \mathbb{R} \to \mathbb{R}, \qquad t \mapsto \det \begin{pmatrix} f(tu_1v_1) & f(tu_1v_2) \\ f(tu_2v_1) & f(tu_2v_2) \end{pmatrix},$$

or more generally for all n?

For $n \times n$ matrices (u_iv_j), this question was explored by Loewner (1960s) in the context of functions acting entrywise to preserve the class of positive semidefinite matrices. This theme has recently resurfaced in the 2010s, and we will answer the above question in two ways: (a) in the analysis setting, for arbitrary smooth functions f; and (b) in the algebraic setting, for all (formal) power series f over an arbitrary commutative ring. The answers provide a bridge from analysis to algebra: lurking within each smooth determinant Δ_f are *all* Schur polynomials – a class of symmetric functions with representation-theoretic content. In particular, from the answer to (b) one recovers well-known symmetric function identities by Cauchy (1840s) and by Frobenius (*Crelle* 1882).

Subhash Bhatt Award Lecture

Total positivity: characterizations and connections

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We will survey some foundational results on totally positive (TP) and totally non-negative (TN) matrices, including by Fekete (1912, following Laguerre 1883), Schoenberg (1930), Gantmacher-Krein (1950), and Brown-Johnstone-MacGibbon (1981). A well-known characterization of TP and TN matrices A is via variation diminution: the number of sign changes of Ax is at most that for x, for all input vectors x. We then present a recent result (2022), which reduces this test set to a single vector for each square submatrix of A.

We next provide an alternate characterization of TP and TN matrices (2021, joint with Kannan and Khare): via the sign non-reversal property, and again involving individual test vectors for each square submatrix. Finally, we present an application: We characterize total positivity via the Linear Complementarity Problem (LCP), and in fact strengthen this to checking the solution set of LCP at a single vector for each submatrix.

B N Waphare Award Lecture

Covering energy of posets and its bounds

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The concept of the covering energy of a poset and its bounds are known. In this paper we obtain a lower bound for the largest eigenvalue of a poset. Moreover, we improve the McClelland type bounds for the covering energy, for some special class of posets.

A. Narsinga Rao Award lecture

Results on finite collection of polygons and a proof of the Jordan curve theorem

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The Jordan curve theorem says that a non intersecting closed curve in the plane divides it into two parts - the inside and the outside. While the statement is fairly intuitive, the proof is far from trivial. There have been multiple proofs of the theorem over the last several decades, including a few formal proofs.

The paper in question attempts a proof using finite polygonal covers of arcs and curves and proves Jordan-like results for these covers by first simplifying the covers so the intersection of polygons is easy to handle.

In my talk I will motivate some of the reasoning behind these results and provide some interesting counterintuitive examples in the realm of curves in the plane. Time permitting, we will get into the details of the proofs.

Invited Talks

Ring Based Encryption with Lucas Sequences

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Some analogues of Euler function, Euler Fermat theorem, quadratic reciprocity etc. with modular Lucas sequences play a vital role in the study of applications with Lucas sequences in cryptography and also in other problems like finding solutions of some Diophantine equations. Smith and Lennon in 1993 proposed RSA like public key cryptosystem with modular Lucas sequences. In this talk we first describe a ring structure on modular Lucas sequences with two operations $*$ and o on the set L_N of modular Lucas sequences for a positive integer $N = p.q$, where p, q are distinct primes and we then propose an encryption with modular Lucas sequences, by exploiting the arithmetic on the ring L_N via the arithmetic on the ring L_p X L_q.

Special affine Fourier transform

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The special affine Fourier transform (SAFT) was first considered by Abe and Sheridan in 1994 in connection with the study of optical wave functions. Many well known transforms such as Fourier transform, Fractional Fourier transform and Fresnel transform are the special cases of SAFT. In this talk, we plan to discuss some interesting results based on SAFT in harmonic analysis and sampling theory.

Large time asymptotics to solutions of some nonlinear partial differential equations

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In this lecture we discuss the large time asymptotics to solutions of some nonlinear partial differential equations - nonhomogeneous Burgers equations and some generalized Burgers equations. Solutions of the nonhomogeneous Burgers equations subject to certain initial profiles are constucted in terms of the self-similar solutions of a variable coefficient linear partial differential equation. One can easily get the large time asymptotic behaviour of the solutions of the nonhomogeneous Burgers equation from the representation written in terms of self-similar solutions. We also discuss the large time asymptotics to the solutions of some generalized Burgers equations.

Scientific Computing through the lens of Cryptography

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A problem in Number Theoretic Cryptography will be prsented highlighting the three aspects of Scientific Computing viz. methods and algorithms for an application problem in Scientific domain, computational methods and high performance computing. Elliptic Curve Discrete Logrithm Problem (ECDLP) forms the core of Public Key Cryptography. It is converted into a linear algebra problem called zero minor problem. One has to find a zero minor of a nonsingular matrix associated with the ECDLP under consideration. Initial Minor Conjecture says it is enough to look at a small set of minors to determine the existence of zero minor. The search was done through computer simulations and the experimental results were encouraging. Theoretical underpinning of the simulations is an open challenge. It will open up applications in other fields.

Reciprocal eigenvalue properties using the Mobius and Zeta functions on Boolean algebras

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Zeta and Möbius functions on partially ordered sets (poset) have classically been studied with a view towards applications to combinatorics and graph theory. A prime example of a poset is Boolean algebra. In this paper, we consider zeta and Möbius functions on Boolean algebras and the posets derived from the Boolean algebras and use these in the study of the spectral properties of Boolean graphs. Boolean graphs can be considered as a generalization of the well known Kneser graphs. Spectral properties of the Boolean graphs were studied by J. LaGrange who proved that these graphs have the reciprocal eigenvalue property and also that this property characterizes the Boolean rings. We show that the adjacency operator of the Boolean graph is the composition of the multiplication operator by zeta function and the complementation operator. This allows us to express the inverse of the adjacency operator in terms of Möbius functions. This technique works not just for the Boolean graphs but also more generally for zero-divisor graphs of complemented subposets of Boolean algebra. As a result we are able to obtain determinants and inverses of associated adjacency operators from the corresponding properties of zeta and Möbius functions as part of the incidence algebra. Furthermore, we identify a class of subposets of Boolean algebras which have a reciprocal eigenvalue property. This produces a large family of graphs having the reciprocal eigenvalue property.

Trace of powers of algebraic numbers

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Abstract: In 1919, G. Polya proved that the given algebraic number α is an algebraic integer if and only if $Tr(\alpha^n) \in \mathbb{Z}$. Then Lame posed a question that if a non-zero algebraic number α satisfies $Tr(\alpha^m) \in \mathbb{Z}\backslash\{0\}$ for infinitely many natural numbers m, is it true that α is an algebraic integer?. This question was solved by Corvaja and Zannier in 2004 and generalized by Philippon and Rath in 2021. We looked into the following problem. *Let $\alpha_1, \ldots, \alpha_n, \lambda_1, \ldots, \lambda_n$ be non-zero algebraic numbers. Does $Tr(\lambda_1\alpha_1^m + \cdots + \lambda_n\alpha_n^m) \in \mathbb{Z}\backslash\{0\}$ for infinitely many natural number m imply that each α_i is an algebraic integer?* One can obtain a counter-example to this question. Thus, we needed to understand that if the linear recurrence sequence $\lambda_1\alpha_1^m + \cdots + \lambda_n\alpha_n^m$ are algebraic integers for infinitely many natural numbers m, then what kind of exhaustive cases arise. Precisely we found what cases arise and we obtain many results in this directions. We also could prove a finite version in the spirit of De Smit when $n = 2$. This is a joint work with A. Bharatwaj, A. Pal and V. Kumar.

Statistical Estimations from Locality Sensitive Hashing (LSH): Adaptive Sampling at the cost of random sampling

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Sampling is one of the fundamental hammers in machine learning (ML) for reducing the size and scale of the problem at hand. Many ML applications demand adaptive sampling for faster convergence. However, the cost of adaptive sampling itself is prohibitive when the sampling weights are changing. This creates a fundamental barrier. In this talk, I will discuss some of my recent and surprising findings on the use of hashing algorithms for large-scale estimations. Locality Sensitive Hashing (LSH) is a hugely popular algorithm for sub-linear near neighbor search. However, it turns out that fundamentally LSH is a constant time (amortized) adaptive sampler from which efficient near-neighbor search is one of the many possibilities. LSH offers a unique capability to do smart sampling and statistical estimations at the cost of a few hash lookups. Our observation bridges data structures (probabilistic hash tables) with efficient unbiased statistical estimations. I will demonstrate how this dynamic and efficient sampling breaks the computational barriers in adaptive estimations, where it is possible that we pay roughly the cost of uniform sampling but get the benefits of adaptive sampling. I will demonstrate the power of a straightforward idea for a variety of problems 1) Adaptive Gradient Estimations for efficient SGD and an orders of magnitude efficient Deep Learning training and inference.

Some Matrix-variate Models Applicable in Different Areas

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Matrix-variate Gaussian type or Wishart type distributions in the real domain are widely used in the literature. When the exponential trace has an arbitrary power and when a factor involving a determinant enters into the model or a matrix-variate gamma type or Wishart type model with exponential trace having an arbitrary power, is extremely difficult to handle. Evaluation of the normalizing constant in such a model is the most important part because when studying the properties of such a model, the method used in the evaluation of the normalizing constant will be the relevant steps in all the computations involved. One such model with a factor involving a trace and the exponential trace having an arbitrary power, in the real domain, is known in the literature as Kotz' model. No explicit evaluation of the normalizing constant in the model involving trace with an exponent and determinant with an exponent entering into the model and at the same time the exponential trace having an arbitrary exponent seems to be available in the literature. The normalizing constant widely used in the literature and interpreted as the normalizing constant in the general model and refers to as a Kotz' model does not seem to be correct. Corresponding model in the complex domain, with the correct normalizing constant, does not seem to be available in the literature. One of the main contributions in this paper is the matrix-variate distributions in the complex domain belonging to Gaussian type, gamma type, type-1 and type-2 beta type when the exponential trace has an arbitrary power. All these models are believed to be new. A second main contribution is the explicit evaluation of the the normalizing constants, in the real and complex domains especially in the complex domain, in a matrix-variate model involving a determinant and a trace as multiplicative factors and at the same time the exponential trace having an arbitrary power. Another main contribution is the introduction of matrix-variate models with exponential trace having an arbitrary exponent, in the categories of type-1 beta, type-2 beta and gamma distributions or in the family of Mathai's pathway models [1], both in the real and complex domains. Another new contribution is the logistic-based extensions of models in the real and complex domains with exponential trace having an arbitrary exponent and connecting to extended zeta functions introduced by this author recently. Some properties of such models are indicated but not derived in detail in order to limit the size of the paper. The techniques and steps used at various stages in this paper will be highly useful for people working in multivariate statistical analysis as well as people applying such models in engineering problems, communication theory, quantum physics and related areas, apart from statistical applications.

Symposium Talks

Commutative Algebra

The Hilbert-Kunz multiplicity of powers of ideals

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Ilya Smirnov conjectured that the Hilbert-Kunz multiplicity of large powers of an $\mathfrak{m}$- primary ideal I in Noetherian local ring $(R, \mathfrak{m})$ can be expressed in terms of the limits of the Hilbert coefficients of the Frobenius powers of I. We will present a partial solution of the conjecture under the assumption that the associated graded rings of Frobenius powers of I have depth at least $\dim R - 1$.

Polynomial invariant rings for finite p-groups

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We will discuss when the invariant rings for finite p-groups are polynomial rings. This is based on joint work with Mandira Mondal.

Unimodular rows

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Let R be a commutative ring with unity. A row vector $u = (a_1, \cdots, a_n) \in R^n$ is called *unimodular* (of length n) if there is a row vector $v = (b_1, \cdots, b_n) \in R^n$ such that $uv^T = 1$, i.e., $a_1b_1 + \cdots + a_nb_n = 1$. Let $Um_n(R)$ denote the set of all unimodular rows of length n. The group $GL_n(R)$ and its subgroups act on $Um_n(R)$ by right multiplication. In this talk we shall discuss several aspects of these actions. Starting from the classical results, we shall give an exposition of some recent works as well.

Singularities in prime characteristics

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For a commutative ring R of prime characteristic p, the map $F : R \to R$ sending $r \mapsto r^p$ is a ring endomorphism, called the Frobenius morphism. Frobenius morphism plays an important role in studying singularities of such rings. The singularities that have been defined in terms of the Frobenius map are called F-singularities. In this talk we will discuss some recent developments of F-singularities.

A$\mathfrak{m}$AC subset of power series ring and its applications

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In this talk we introduce the notion of AmAC subsets of power series ring. We then use these to prove a generalization of Gurjar's Hyperplane section theorem and "*Milnor number on Tjurina number constant family is bounded*". All terms stated will also be defined.

Controllability and Differential Equations

Controllability of Singular Switched Differential Equations on Non-uniform Time Domain

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In this talk, we introduced the time scales theory and used it to study the controllability results of the singular switched system on time scales. We evaluate the solution of slow-switched subsystem and fast-switched subsystem by using the mathematical induction. Also, we investigate the necessary and sufficient condition for controllability result of singular switched system followed by the state response of the fast-switched and slow-switched subsystems. In the end, we gave an example to illustrate the application of these results.

Control and Machine Learning

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In this lecture, we shall present some recent results on the interplay between control and Machine Learning, and more precisely, Supervised Learning and Universal Approximation. We adopt the perspective of the simultaneous or ensemble control of systems of Residual Neural Networks (ResNets). Roughly, each item to be classified corresponds to a different initial datum for the Cauchy problem of the ResNets, leading to an ensemble of solutions to be driven to the corresponding targets, associated with the labels, by means of the same control. We present a genuinely nonlinear and constructive method, allowing us to show that such an ambitious goal can be achieved, by estimating the complexity of the control strategies. This property is rarely fulfilled by the classical dynamical systems in Mechanics and the very nonlinear nature of the activation function governing the ResNet dynamics plays a determinant role. It allows deforming half of the phase space while the other half remains invariant, a property that classical models in mechanics do not fulfill.

Controllability of LTI Networked Systems

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The complex networked systems have been extensively studied over the last half a century, because of their ubiquity encountered in nature and society. Although various criteria for the controllability of the stand-alone system systems are well developed, the controllability issues for LTI systems become more complicated and challenging due to their structural complexity. In this talk , various criteria for controllability of LTI-networked systems with homogeneous nodes and well as heterogeneous nodes are discussed. The spectral properties of the connection matrices and the node matrices are invoked for obtaining the controllability conditions. Nonlinear perturbations of LTI systems are also considered for controllability study. Numerical examples are provided to illustrate the controllability results.

Controllability results for Hilfer fractional differential equations via measure of noncompactness

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In this talk, we discuss the controllability of ψ-Hilfer fractional differential Equations (FDEs) with infinite delay. Sufficient conditions for controllability results are obtained by using the notion of the measure of noncompactness (MNC) and the Monch fixed point theorem. We also discuss the controllability of Hilfer fractional differential Equations via Schauder type fixed point theorem. Finally, we provide a numerical example to illustrate our main results.

Optimal control results for second order differential equations

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In this talk some sufficient conditions for the optimal control problems for the second-order semilinear differential equations in Hilbert spaces.
Consider the integral cost function as

$$J(z,v) := \int_0^T L(t, z^v(t), v(t))dt,$$

subject to the equations

$$\begin{aligned} z''(t) &= Az(t) + Bv(t) + g(t, z(t));\ 0 < t \leq T \\ z(0) &= z_0 \\ z'(0) &= z_1. \end{aligned}$$

First, we discuss the existence and the uniqueness of mild solutions for the above proposed problem using Banach fixed point theorem. The stated Lagrange's problem admits at least one optimal control pair under certain assumptions. The results are obtained via basics of functional analysis, Balder's theorem, and the cosine family.

Harmonic Analysis

Uncertainty principle for solutions of the Schrödinger equation

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The Uncertainty Principle for a function f and its Fourier transform $\hat{f}$ is a central phenomena in Euclidean harmonic analysis. Consider the Schrödinger equation on $\mathbb{R}^n$:

$$i\partial_t u(x,t) + \Delta_x u(x,t) = 0, \quad u(x,0) = u_0(x).$$

Then any Uncertainty Principle for the pair $(f, \widehat{f})$ can be restated in terms of an Uncertainty Principle for (u_0, u_1), where $u_1(x) = u(x,1)$. In this talk, we will deal with the Schrödinger equation associated to the sublaplacian on the Heisenberg group. Besides considering certain Uncertainty Principle for solutions of the free Schrödinger equation on the Heisenberg group, we will see the influence of the potential.

Bilinear maximal functions associated with degenerate surfaces

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We study $L^p \times L^q \to L^r$-boundedness of (sub)bilinear maximal functions associated with degenerate hypersurfaces. First, we obtain the maximal bound on the sharp range of exponents p, q, r (except some border line cases) for the bilinear maximal functions given by the model surface $\big\{(y,z) \in \mathbb{R}^n \times \mathbb{R}^n : |y|^{l_1} + |z|^{l_2} = 1\big\}$, $(l_1, l_2) \in [1,\infty)^2$, $n \geq 2$. Our result manifests that nonvanishing Gaussian curvature is not good enough, in contrast with L^p-boundedness of the (sub)linear maximal operator associated to hypersurfaces, to characterize the best possible maximal boundedness. Secondly, we consider the bilinear maximal function associated to the finite type curve in $\mathbb{R}^2$ and obtain a complete characterization of the maximal bound. We also prove multilinear generalizations of the aforementioned results.

Fixed time estimates for Hermite semigroup in Lebesgue and modulation spaces

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In this talk, we shall discuss some fixed time estimates for the Hermite-semigroup when acting on Lebesgue and modulation spaces. We will give an overview of the progress in the last decade and ongoing interest in the context of Lebesgue and modulation spaces.

Multilinear Fourier integral operators on modulation spaces

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Abstract

In this article, we study properties of multilinear Fourier integral operators on weighted modulation spaces. In particular, using the theory of Gabor frames, we study boundedness of multilinear Fourier integral operators on products of weighted modulation spaces. Further, we investigate the periodic multilinear Fourier integral operator. Finally, we study continuity of bilinear pseudo-differential operators on modulation spaces for certain symbol classes, namely SG-class.

Boundedness of pseudo-differential operators on graded Lie groups

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In this talk, we will discuss the boundedness of pseudo-differential operators associated with the global Hörmander symbol classes on the graded Lie groups. We provide both necessary and sufficient conditions for the L^p-L^q boundedness of pseudo-differential operators associated with the global Hörmander symbol classes on graded Lie groups, within the range $1 < p \leq 2 \leq q < \infty$. Additionally, we present a sufficient condition for the L^p-L^q estimates of pseudo-differential operators within the range $1 < p \leq q \leq 2$ or $2 \leq p \leq q < \infty$. We will also discuss some applications of the aforementioned results.

Vertical operators on Bergman space over UHP

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Let Π be the upper half-plane. In this talk, we prove that every vertical operator on the Bergman space $A^2(\Pi)$ over the upper half-plane can be uniquely represented as an integral operator of very special form. The talk is based on joint work with Co Author's: Shubham R Bais, Mohan P.

Hyperbolic PDEs and Shock Waves

Initial boundary value problem for 1D scalar balance laws with strictly convex flux

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Abstract

By introducing a suitable boundary functional, we obtain a Lax-Oleĭnik type formula for the initial-boundary value problem for a balance law. We show that the explicit solution given by Lax-Oleĭnik formula is entropy admissible and satisfies the initial condition in a strong sense and boundary condition in the sense of Bardos, le Roux, and Nédélec.

Interaction of shock waves in a conservation law without convexity

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Abstract

We investigate the intricate dynamics of wave propagation governed by a conservation law without convexity. In particular, we focus on the study of complexities that arise from wave interactions in the solution of the Riemann problem having multiple discontinuities. The presence of more than one inflection point in the flux function yields some new and unconventional results such as bifurcation of shock waves and generation of new centered rarefaction waves during the interaction of composite waves originating from the different discontinuities. The present study advances our theoretical understanding of nonlinear wave dynamics and provides valuable insights for predicting and controlling wave behavior in diverse areas of science.

Insight into symmetries and their applications to Partial Differential Equations

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The presentation starts with a general introduction to symmetries and partial differential equations (PDEs). As researchers constantly look for analytical solutions for PDEs, it is worth exploring the research area of applications of symmetries to PDEs. With a historical background of this area of research, the main applications are discussed. Further, various types of symmetries are addressed along with their advantages and disadvantages. Moreover, a particular class of symmetry, i.e., nonlocal symmetry, is focused to do further analysis, and a few new exciting results are also emphasized for discussion. Finally, some open problems are brought to the attention of researchers.

Interaction of shocks in drift-flux equations of two-phase flows

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In this talk, we consider the interaction of arbitrary shocks in the isothermal drift-flux model of two-phase flows. Here, we use the results of the Riemann solution and weak shock interaction to investigate the interactions between arbitrary shocks. Further, we use the property of the Riemann invariant and reduce the system of equations by taking the projection of elementary waves in the phase plane. Finally, we investigate the interactions of arbitrary shocks in this phase plane.

Two-dimensional Riemann problem and wave interactions in a thin film model of a perfectly soluble antisurfactant solution

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Abstract

We consider the Riemann problem and nonlinear wave interactions in a thin film model of a perfectly soluble antisurfactant solution. We develop six geometrically different structures of the solution using generalized characteristic analysis method while relaxing the restriction that only one planar elementary wave is developed at the interface of each initial discontinuity. We analyze the interactions of classical and nonclassical waves in detail to construct the global solution of the corresponding 2-D Riemann problem.

Delta Shocks and vacuum states in the Riemann solutions of Chaplygin Euler equations as pressure and magnetic field drop to zero

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The aim of the present study is to solve the Riemann problem of isentropic magnetogasdynamics equations for a more realistic version of the extended Chaplygin gas model. The analysis demonstrates that under some special circumstances, delta shock and vacuum appear in the solution, describing the phenomena of concentration and cavitation, respectively. By examining the limiting behavior, it is obtained that solutions coincide with corresponding Riemann solutions of the transport equations when both the magnetic field and pressure drop to zero.

Recent Trends in Graph Theory

Product cordial and signed product cordial graphs

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Let $G = (V, E)$ be a graph such that $|V(G)| = n$ and $|E(G| = m$, where $V(G)$ and $E(G)$ are called the vertex set and edge set of G. Cordial labeling of graphs was introduced by Cahit in 1987. Let each vertex be labeled with a zero or one. The label of each edge is the absolute difference of the labels of its end vertices. Now, if the absolute difference between the number of vertices labeled with one and the number of vertices labeled with zero differs by at most one and if the absolute difference between the number of edges labeled with one and the number of edges labeled with zero also differs by at most one, then the labeling is said to be a cordial labeling. A graph for which we can find a cordial labeling is known as a cordial graph. The trees, complete bipartite graphs, pinwheels, ladders etc. are all cordial graphs. Cordiality in various types of graphs has been extensively studied since 1987. Now suppose that the label of each edge is the product of the labels of its end vertices. Now, if the absolute difference between the number of vertices labeled with one and the number of vertices labeled with zero differs by at most one and if the absolute difference between the number of edges labeled with one and the number of edges labeled with zero also differs by at most one, then the labeling is said to be a product cordial labeling. A graph which admits such a labeling is known as a product cordial graph. This concept was introduced in 2004 by Somasundram et al. Let each vertex be labeled with '+' or $'-'$ sign. The label of each edge is the product of the signs of its end vertices. Now, if the absolute difference between the number of vertices labeled with '+' and the number of vertices labeled with $'-'$ differs by at most one and if the absolute difference between the number of edges labeled with '+' and the number of edges labeled with $'-'$ also differs by at most one, then the labeling is said to be a signed product cordial labeling. A graph which admits a signed product cordial labeling is known as a signed product cordial graph. This concept was introduced by Babujee and Loganathan in 2011. The main aim of this talk is to interrelate these two concepts and unify the existing results related to both the labelings.

Van der Waerden type results in Ramsey Theory

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In this talk basic results in Ramsey Theory will be stated and a common proof for many Van der Waerden type results will be presented.

Matching with preferences: Stable Matching and Beyond

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Given n men and n women and each man M has a total preference order over all the women and similarly, each woman W has a total preference order over the men. We will write p ¡a q if according to person a 0 s preference, p is less desirable than q. We will assume for now that there are no ties, i.e., preference orders are strict. In the SM setting, we consider a complete bipartite graph between the men and women. Before discussing the definition of stable, we define the following, Definition 1 (Blocking pair). Given a matching M, a pair (m, w) is a blocking pair for M if (m, w) / M and m prefer w to its current partner in M (or m is unmatched in M) and w prefers m over its current partner in M (or w is unmatched in M).

A Roman $\{3\}$-dominating function (Double Italian dominating function) of a graph $G = (V, E)$ is a function $f : V \to \{0, 1, 2, 3\}$ having the property that for every vertex $v \in V$, if $f(v) = 0$, then $\sum_{u \in N(v)} f(u) \geq 3$ and if $f(v) = 1$, then $\sum_{u \in N(v)} f(u) \geq 2$. The weight, $f(V)$, of a Roman $\{3\}$-dominating function f is $\Sigma_{u \in V} f(u)$. The minimum weight of a Roman $\{3\}$-dominating function in a graph G is known as *Roman* $\{3\}$*-domination number* of G and is denoted by $\gamma_{\{R3\}}(G)$. Minimum Roman $\{3\}$-Domination problem is to find a Roman $\{3\}$-dominating function of minimum weight and Decide Roman $\{3\}$-Domination is the decision version of Minimum Roman $\{3\}$-Domination problem. Decide Roman $\{3\}$-Domination is known to be NP-complete for bipartite graphs. In this paper, we show that Decide Roman $\{3\}$-Domination is NP-complete for chordal graphs and chordal bipartite graphs. We show that Minimum Roman $\{3\}$-Domination problem is polynomial-time solvable for threshold graphs which is a subclass of chordal graphs. We propose an $O(\ln \Delta(G))$ approximation algorithm for Minimum Roman $\{3\}$-Domination problem for a graph G with maximum degree $\Delta(G)$. We show that Minimum Roman $\{3\}$-Domination problem cannot be approximated within $(1 - \epsilon))lnn$ for any $\epsilon > 0$ unless $P = NP$. Finally, we show that Minimum Roman $\{3\}$-Domination problem is APX-complete for bounded degree graphs.

A graph theoretic model for a generic three jug puzzle

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In a classic three jug puzzle we have three jugs A, B, C with some fixed capacities say 8, 5, 3 liters respectively. The jug A is completely filled with wine to its capacity. The goal is to divide the wine into two equal halves by pouring it from one jug to another without using any other measuring devices. This particular has a known solution. However, we consider a generic three jug puzzle and present a graph theoretic model to determine whether the puzzle has a solution at first place. If it has a solution, then the same can be determined using this model.

On Local Distance Antimagic Coloring of Graphs

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Let $G = (V, E)$ be a simple connected graph with $|V| = n$ and $|E| = m$. A bijection $f : E \to \{1, 2, \ldots, m\}$ is called a local antimagic labeling if for any two adjacent vertices u and v, $w(u) \neq w(v)$, where $w(u) = \sum_{e \in E(u)} f(e)$, and $E(u)$is the set of edges incident to u. It is clear that this local antimagic labeling induces a proper vertex coloring of G where the vertex v is assigned the color $w(v)$. The *local antimagic chromatic number* $\chi_{la}(G)$ is the minimum number of colors used over all colorings of G.
Let $f : V(G) \to \{1, 2, \ldots, n\}$ be a bijection. For every vertex $v \in V(G)$, we define the weight of vertex v as $w(v) = \sum_{x \in N(v)} f(x)$. Then f is said to be a locally distance antimagic labeling of G if $w(u) \neq w(v)$ for every pair of adjacent vertices $u, v \in V(G)$. A graph which admits such a labeling is said to be a local distance antimagic graph. Clearly this labeling f induces a proper vertex coloring of the graph G. For a local distance antimagic graph G, we define the local distance antimagic chromatic number $\chi_{ld}(G)$ as the minimum number of vertex weights induced by a labeling f over all locally distance antimagic labelings of G. If G does not admit a local distance antimagic labeling then $\chi_{ld}(G) := \infty$. In this presentation, we shall discuss results on local (distance) antimagic chromatic number and its other variations of some graphs.

Theoretical Astrophysics & Cosmology

Super-Chandrasekhar white dwarf, its mass-limit and consequences

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I plan to report, based on a series of publications by our group in past decade or so, that magnetized stars can evolve to highly magnetized white dwarfs by stellar evolution with a suitable initial magnetic field configuration. Our theory and simulation show that the mass of magnetized white dwarfs can well pass the 1.4 solar mass Chandrasekhar mass-limit and, depending on field strength and profile, lead to a variety of mass-radius relations. Therefore, the 1.4 solar mass-limit does not seem to be sacrosanct, as predicted by several observations of type Ia supernovae (SNeIa) in the last two decades. This urges caution when using white dwarfs associated with SNeIa as standard candles.

Cosmological Tensions and Hints for New Physics

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Recently different low redshifts measurements have indicated tensions in the standard $\wedge$CDM model. In this talk, I shall review these cosmological tensions in the $\wedge$CDM model and discuss the indications of new physics beyond the $\wedge$CDM model to address these tensions.

Some comments on dark energy

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The discovery of the late-time acceleration of the universe is one of the most important recent discoveries in cosmology. Despite a lot of research efforts that have gone in to try to explain this phenomenon, the cause of this acceleration is still not clear. There are two main ways in which to explain the accelerated expansion of the universe. The one is to postulate some kind of "exotic" matter, dubbed dark energy, which has negative pressure, and hence causes the acceleration. There is no shortage of candidates for dark energy. In Einstein's theory of general relativity, the candidate is the cosmological constant. Despite being the most popular explanation for the acceleration, there are some problems which cannot be explained satisfactorily. The other alternative method is to study modified theories of gravity apart from Einstein's theory. In almost all of these theories, there are one or more assumptions that are usually made. In this talk, we focus on some of these assumptions, and compare them to try to analyse which would be the most appropriate.

Outstanding issues in modern cosmology

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Four major epochs are attributed to the history of the universe, with four outstanding problems associated with each one: inflation (issues related to initial conditions); radiation domination (baryogenesis); matter domination (the nature of dark matter); and late-time acceleration (the nature of the exotic matter/gravity modifications that cause acceleration). Keeping the level of discussion non-technical, we shall focus on the mentioned issues.

Wormhole and Galactic halo dark matter

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Rahaman et al. (Rahaman 2014, 2016) have used NFW (Navarro 1996) and URC (Castignani 2012) dark matter density profiles to investigate the existence of wormholes in the halo region of the Galaxy. Also, Övgün et al. (Ali 2016) have tried to demonstrate the existence of wormhole in the galactic region by using Einasto model (Einasto 1965, 1989). Xu et. al (Xu 2020) have also shown about the possible existence of wormhole in galactic halo region by using Navarro-Frenk-White (NFW), Thomas-Fermi (TF) and Pseudo Isothermal (PI) dark matter density profiles. Here, we have investigated the existence of wormhole in the halo region of dwarf and massive spiral galaxies with different morphologies, masses, sizes and gas fractions by taking observed flat rotation curves as input. We assume Singular Isothermal Sphere (SIS) dark matter density profile (Keeton 2002). We calculate v2halo from fitting the rotation curves of the SPARC sample of galaxies (Lelli 2016) using 25 dwarf galaxies and 25 massive spiral galaxies. This result confirms the possible existence of wormholes in both dwarf and massive spiral galaxies.

A Mathematical Framework for Transforming a Static Wormhole into a Rotating Wormhole

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Recently, it is argued that Sagittarius A* (complex radio source at the center of our galaxy, Milky Way) contains either a supermassive black hole or a supermassive type I wormhole. So, it is a challenge for the theoretical Astrophysicists to construct rotating black hole or wormhole solutions. In literature, so many rotating black holes are found either in general relativity or modified theory of gravity. Only a few rotating wormhole solutions have been constructed so far. Therefore, constructing of Rotating traversable wormhole is an active area of research in recent time . In this construction of a rotating traversable wormhole solution, we use Newman-Janis Algorithm (NJA) without solving Einstein's field equations. Here we have assumed the matter distribution satisfying the isotropic condition.

Cosmological Concepts in Religious Text

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This talk is motivated by the theme "Indian knowledge system Gyan , Vigyan and Darshan" of National Education Policy -2020. We try to explore the basic cosmological concepts given in our religious texts. We start with the theory of origin of universe in Rigveda then Big bang , Big crunch , Big bang cycle and Black holes in Sreemad Bhagwat Gita. In next part we talk about the concepts of uniform distribution of matter in universe, dark matter , dark energy available in epic Mahabharat. We will try to explain modern theory of cosmology in context of Holy Quran and theory of creation of universe in Bible. We know that our country has a rich heritage of astronomy and astrophysics since Vedic age. We talk briefly about the work of Aryabhatta & Varamihir in the light of different gravitational theory available presently.

Papers for Competition Session

IMS Prize Group 1

An Edge Labeling Problem of Graphs

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In this paper a new edge labeling, namely AR labeling is introduced motivated from Rado's theorem. Let $f : E \to \mathbb{N}$ be an edge labeling of a graph G. A vertex v is called an AR vertex, if v has distinct edge weight sums for each distinct subset of edges incident on v. i.e., if $\{x_1, x_2, \ldots, x_k\}$ are the edge labels of the edges incident on v, then the 2^k subset sums are all distinct. An edge labeling f of a graph G is said to be an AR labeling of G if $f : E \to \mathbb{N}$ is such that every vertex in G is an AR vertex under f. The minimum k such that there exists an AR labeling $f : E \to \{1, 2, 3, \ldots, k\}$ is called the AR index of G, denoted by $ARI(G)$. A graph G is said to be an AR graph if $ARI(G) = m$, where m is the number of edges of G. A study of AR labeling and AR graphs is initiated in this paper.

Characterization for connectedness of essential element graph of a lattice

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In this paper, we introduce the concept of a UE-lattice. We give two equivalent condition for a lattice to be a UE-lattice. We study essential element graphs of lattices obtained by linear sum, vertical sum, horizontal sum and adjunct of lattices. We discuss connectedness of the essential element graphs of complemented, modular and distributive, lattices. For the class of finite lattices, we obtain a characterization for the essential element graph of a lattice L to be connected.

V M Shah Prize

Approximation of conjugate Fourier series for function in generalized Hölder class by K^λ means

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We study the approximations of conjugate Fourier series for a function in generalized Hölder class $H_{\xi,p}$ using Karamata K^λ means.

IMS Prize Group 4

Approximation of nonlinear Ill-posed equations in Hilbert space using Traub-like methods

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Traub-like iterative scheme of order four is proposed for approximately solving the nonlinear ill-posed operator equation involving a monotone operator in Hilbert space. Using Lavrentiev regularization method solutions with optimal order of convergence is obtained, on utilizing a source condition and apriori parameter choice strategy as given by S, George et.al. Numerical example is presented, which justifies the analysis.

IMS Prize Group 5

Gaussian noncommutative wormhole solutions in $f(Q,T)$ gravity with conformal symmetry

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This study introduces novel and physically plausible solutions for wormholes within the framework of $f(Q,T)$ gravity theory, featuring the integration of conformal symmetries and Gaussian non-commutativity. The investigation explores the potential of traversable wormholes across various scenarios, encompassing traceless and barotropic equations of state (EoS). Moreover, a comprehensive analysis of the impact of model parameters on the presence and characteristics of these wormhole structures is undertaken. Significantly, the resultant shape function satisfies all essential criteria. Furthermore, in one scenario, the presence of non-exotic fluid is established.

IMS Prize Group 6

Eyes on the Prize: Modeling Isolation and Hygiene Compliance for Taming the Direct and Indirect Transmission of Conjunctivitis

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In the title of article, "Eyes on the Prize" is used metaphorically to convey the idea of maintaining focus and determination on achieving a specific goal or objective related to conjunctivitis control, i.e., cost-effective optimal strategies for tumbling down the eye flu transmission. In this case, the"prize" refers to the successful prevention and control of conjunctivitis transmission through modeling and cost-effective measures involving hygiene and isolation. The pictorial abstract below effectively illustrates the precise aim of the article.

This article discusses an economical analysis of optimal control strategies applied on a deterministic compartmental model of SEIR-type, which represents both direct and indirect transmission of conjunctivitis (viral/bacterial eye flu). The model takes into account factors such as immunity decay and the influence of environmental irritants. In the study, two time-dependent measures, isolation and hygiene compliance, are introduced as control variables within the model to formulate an optimal control problem (OCP). Alongside examining basic qualitative characteristics like positivity and boundedness, the article also calculates the reproductive threshold, R_0, using the next-generation method, and investigates how these control measures impact it. The paper demonstrates the existence and characterization of optimal controls, a crucial step in establishing the optimality system. Solving the OCP is achieved through the application of the forward-backward sweep method, and the obtained results are subsequently simulated using MATLAB. The comparative cost-effectiveness analysis suggests that the most efficient and enduring approach to rapidly reduce eye flu infection is the simultaneous implementation of both control strategies, as compared to implementing them individually. This paper provides valuable insights that can support policymakers and public health experts in crafting precise and effective strategies for managing conjunctivitis and disseminating awareness accordingly.

Section A : Combinatorics, Graph Theory, Logic, Discrete Mathematics

A2] Idempotents in Matrix Ring Over Field and Its Applications

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Let $\mathbb{F}$ be a finite field and $R = M_2(\mathbb{F})$ be 2×2 matrix ring over $\mathbb{F}$. In this paper, we explicitly determine all the idempotents in R. Using these idempotents, we study the idempotents graph of R whose vertex set is the set of non-trivial idempotents in R and two idempotents e, f are adjacent if $ef = 0$ or $fe = 0$. It is prove that the idempotent graph of R is regular. Further, we determine the Wiener and Harary index of the idempotent graph of R.

A3] Exploring Zagreb Indices of the Zero-divisor Graph of the Ring $\mathbb{Z}_n$

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The zero-divisor graph of a ring R is a graph whose vertex set consists of all elements of R and distinct vertices x and y are adjacent if and only if xy = 0. We study the zero-divisor graph $\Gamma_0(\mathbb{Z}_n)$ and compute first and second Zagreb indices, multiplicative Zagreb indices, Zagreb coindices indices, multiplicative Zagreb coindices indices of zero-divisor graph $\Gamma_0(\mathbb{Z}_n)$.

A4] Error Detection Cyclic Redundancy Check of Fractal Graphs

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This article explores the fascinating interplay between fractal geometry and error detection codes, with a focus on the lexicographic zero divisor graphs. The author investigates to construction of lexicographic zero divisor graphs and uncover their intrinsic fractal properties. The lexicographic product of zero divisor graphs, a novel concept, demonstrates self similarity and recursive patterns reminiscent of fractal structures. As a consequence, the author flourish the beautiful results that, all the lexicographic product of zero divisor graphs are fractal graphs with suitable illustration. Moreover, demonstrate that all zero divisor graphs are not fractal graphs. Furthermore, examine the integration of cyclic codes using fractal graphs. Cyclic codes are well known for their error correction and detection capabilities and are widely employed in various data transmission systems. Along with, this article initiate an innovative extension of the Diffie Hellman key exchange algorithm, a class of error detecting codes, to enhance its security and reliability for a cyclic codes too.

A5] Bounds for the vv-degree based first Zagreb index of graphs

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A topological index is a graph invariant applicable in chemistry. The first Zagreb index is a topological index based on the vertex degrees of molecular graphs. For any graph G, the first Zagreb index $M_1(G)$ is equal to the sum of squares of the degrees of vertices. A block in a graph G is a maximal connected subgraph of G that has no cut-vertices. Two vertices $u, w \in V(G)$ are said to be vv-adjacent if they incident on the same block. The vv-degree of a vertex u, denoted as $d_{vv}(u)$, is the number of vertices vv-adjacent to u. The first vv-Zagreb index $VVM_1(G)$ is a topological index based on the vv-degrees of vertices, defined as $VVM_1(G) = \sum_{u \in V(G)} d_{vv}(u)^2$. In this paper, we investigate classes of graphs with minimum and maximum values of $VVM_1(G)$. Also, we obtain a lower and upper bound for the first Zagreb index $M_1(G)$ for some classes of graphs. Further, we obtain lower and upper bounds on $VVM_1(G)$ in terms of the number of vertices, number of blocks, and maximum vv-degree of G using some classical inequalities.

A7] k-isolate domination and operations of graphs

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The concept of k- isolate domination is known. In this paper, the concept of zero isolate dominating graph (ZID) is introduced. A necessary and sufficient conditions for union and join of two graphs to be ZID graph are obtained. Also necessary and sufficient condition for a subset S of $G + H$ to be an isolate dominating set for $G + H$ are obtained.

A8] Application On Neutrosophic Fuzzy Soft Matrix Devicing System in Cryptography

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Matrix theory is important in many fields of science and engineering, however it cannot handle indeterminate (or) inaccurate problems. Neutrosophic fuzzy soft matrix is a recent concept designed to tackle indeterminate problems in this circumstance. We introduce the operator of Hadamard product of Neutosophic fuzzy soft matrix in this article. A cryptosystem on Neutrosophic fuzzy soft matrix is explained to evaluate the proposed product in Neutrosophic fuzzy soft matrix. At the moment, social media plays an essential role in our daily lives via the Internet, but there are some drawbacks in terms of security. A strong security system is given in this application with Neutrosophic fuzzy soft matrix in coding and decoding of a communicative message.

A9] Quantifying Molecular Attributes: "Topological Indices Analysis of Saturated Fatty Acids"

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A topological index serves as a quantitative measure that characterizes the topology of a graph G. When applied to the molecular structures of chemical compounds, it precisely encapsulates the theoretical attributes of these substances. This research employs well-established degree-based topological indices to analyze saturated fatty acids' chemical structures. Here, the chemical structure is represented as a graph, where each element functions as a vertex and the bonds between them as edges, excluding hydrogen. Furthermore, the study conducts a quantitative structure-property relationship (QSPR) analysis of these topological indices, revealing a robust correlation between these indices and the physical attributes of saturated fatty acids. This theoretical study holds the potential to aid chemists and professionals across various sectors in predicting the characteristics of saturated fatty acids without relying on experimental procedures.

A10] Jumping times are cycle lengths

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It is known that certain patterns of initial portions of the orbits guarantee the existence of periodic points of certain periods. For example, for an interval map $f : I \to I$, if $f^2(x)$ is between x and $f(x)$ then f has a fixed point. If x is between $f^2(x)$ and $f(x)$ then f has a 2-cycle. If $f^3(x) < x < f(x) < f^2(x)$ then f has a periodic point of period 3. The latest result in this sequence states that if x is between $f^n(x)$ and $f(x)$, for some odd integer $n > 1$, then there is y such that $f^n(y) = y$.

In this paper we define the jumping time of x as the least positive integer n for which $f(x)$ and $f^n(x)$ are on opposite sides of x.i.e., the time taken by x to jump from one side of it to the other side of it. We prove that if n is the jumping time for some $x \in I$ then f has a periodic point say y of period n (even when n is not odd). Moreover y can be so chosen that, $\{f^k(x)\}_{k=0}^{n-1}$ and $\{f^k(y)\}_{k=0}^{n-1}$ are of same order type.

A11] Independence Fractals in Partial Metric Space

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The generalization of metric space whose self-distance is non-zero is called the partial metric space, and it is defined as the set X together with a partial metric on it. Steve G. Mathews first introduced the idea of partial metric space in 1992. For each graph, independence fractals are employed to associate fractals. That is, for graph G, the roots of its independence polynomial are approaching to its Julia set of independence polynomial. Since all graphs have an independence polynomial, they also have an independence fractal. This paper, discusses the results regarding independence fractals in partial metric spaces.

A13] On the dual of splitting p-matroids

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In the present work p-matroid refers to a matroid representable over prime field $GF(p)$. For a p-matroid M and a pair a, b of its elements, it is known that $(M^*)_{a,b} \neq (M_{a,b})^*$. In this paper, we characterize those p-matroids M, where the equality holds true.

A14] Optimizing Wireless Sensor Networks: An Approach Using Centrality Measures for Enhanced Routing Efficiency and Reliability

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Wireless sensor networks (WSNs) play a crucial role in diverse applications, necessitating robust routing protocols for optimal performance. This paper introduces an innovative strategy to enhance WSN efficiency by leveraging centrality measures, including degree centrality (DC), betweenness centrality (BC), closeness centrality (CC), eigenvector centrality (EVC), and Katz centrality (KC). Focusing on networks generated with 100 and 150 nodes using a random graph model, our study explores how centrality metrics impact routing decisions, aiming to optimize energy consumption, reduce latency, and enhance overall network reliability.

A17] P^k Path Eigenvalues of Some Graphs and Related Results

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In 2016, Shikare et. al, introduced the path matrix concept for simple graph G on vertex set $V(G) = \{v_1, v_2, \ldots, v_n\}$. The path matrix $P = (p_{ij})$ of size $n \times n$ such that p_{ij} is equal to the maximum number of vertex disjoint paths from v_i to v_j if $i \neq j$, and $p_{ij} = 0$ if $i = j$. This matrix, denoted as $P(G)$, was termed the path matrix of G. Building upon this, in 2023, Sabeti et. al introduced the concept of P^k path matrix of length k for graph G on n vertices. The P^k matrix, denoted as $P^k = (P^k_{i,j})$ of size $n \times n$ is defined such that $(P^k_{i,j})$ represents the maximim number of vertex disjoint paths of lenght k from v_i to v_j if $i \neq j$ and $(P^k_{i,j}) = 0$ if $i = j$. This paper explores the path spectrum of the P^k path matrix of lenght k for specific classes of graphs, delving into their path energies.

A18] Repeated-root constacyclic codes over finite field

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Cyclic and negacyclic codes form important classes of linear codes containing many optimal codes, and have good error-correcting properties. Due to these properties, cyclic and negacyclic codes can be effectively encoded and decoded using linear shift registers, which justify their preferred role in engineering. Constacyclic codes form a well-known class of linear codes, and are generalizations of cyclic and negacyclic codes. In this research work, we establish the structure of all constacyclic codes of length $4l^m p^n$ over the finite field F_q in terms of their generator polynomials, where p, l are distinct odd primes, q is a power of p and m, n are positive integers. We also determine their dual codes, and all self-dual, self-orthogonal and complementary- dual constacyclic codes of length $4l^m p^n$ over F_q:

Section B : Algebra, Number Theory, Lattice Theory and History of Mathematics

B1] On groups with a given inner automorphism group

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In this paper, among other results, we have characterised groups whose inner automorphism group is isomorphic to A_4, S_4, A_5, a group of order p^3 etc. (p being a prime). As an application, upto isoclinism, we have classified groups having less than ten element centralizers.

B3] Commutativity of rings and Banach algebras with derivations

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The objective of this paper is to discuss the commutativity of a prime ring R with centre $Z(R)$, which admits a generalized derivation f associated with a non zero derivation d such that $f([x^m, y^n]) \pm [x^m, y^n] \in Z(R)$ for all $x, y \in R$. Finally, we apply these purely ring theoretic results to obtain commutativity of Banach algebra. In particular, we prove that if A is a prime Banach algebra which admits a continuous linear generalized derivation f associated with a nonzero continuous linear derivation d such that either $f([x^m, y^n]) - [x^m, y^n] \in Z(A)$ or $f([x^m, y^n]) + [x^m, y^n] \in Z(A)$, for an integer $m = m(x, y) > 1$ and sufficiently many x, y in A, then A is commutative.
IMS subject classification are listed for your information.

B5] Sixteen-dimensional sedenion-like associative algebra

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Christian introduced an eight dimensional octonion like associative normed division algebra over $\mathbb{R}$. There is a controversy that this octonion like algebra contradicts well known Hurwitz theorem, which states that $\mathbb{R}$, $\mathbb{C}$, $\mathbb{H}$ and $\mathbb{O}$ are the only four normed division algebras over $\mathbb{R}$. Khalid and Bouchard noted that octonion like algebra is a seminormed division algebra, i.e. division by any number X in octonion like algebra is possible if and only if $\|X\| \neq 0$, therefore it does not contradict the Hurwitz theorem. This octonion like algebra is different from the algebra of octonions $\mathbb{O}$ as it is associative and has 6 imaginary and two real units where as the algebra of octonions $\mathbb{O}$ is non-associative and has 7 imaginary and 1 real units.

In this article, we generalized the octonion-like algebra and gave a 16-dimensional sedenion-like algebra which is an even subalgebra of 2^5-dimensional Clifford algebra $Cl_{5,0}$. Sedenion-like algebra is different from the algebra of sedenion as it is associative and has six imaginary and ten real units, while the algebra of sedenions have one real and fifteen imaginary units. We split the 16-dimensional sedenion number as dual of octonion like numbers and defined norm on it. We also proved that the octonion-like as well as sedenion-like elements S, T preserves the condition $\|ST\| = \|S\|\|T\|$ and $SS^\dagger$ is commutative [i.e. $SS^\dagger = S^\dagger S$ and $(SS^\dagger)T = T(SS^\dagger)$]. Associativity of sedenion-like algebra is an important property for the physical application of algebras. Jordan attempted to use the algebra of octonions and sedenions to transfer the probabilistic interpretation of quantum theory in dimension 8 and 16 respectively, which was not successful due to non-associativity of the octonions and sedenions. Due to the associativity of octonion-like and sedenion-like algebras, these can be used to transfer the probabilistic interpretation of the quantum theory in Jordan problem.

B10]Vanishing coefficients and algebraic relations of the continued fraction of order 18, 26 and 30

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In the present work, we established continued fractions of level eighteen, twenty six and thirty. Further, we obtained vanishing coefficients and many algebraic relations. To validate our result colored partitions are also obtained.

B11] Reduced Grobner basis with double exponential cardinality

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In this article, we investigate the cardinality of Gröbner basis under various orderings. We identify a family of polynomials and a criterion for the monomial orderings such that the reduced Gröbner basis is double exponential in cardinality. We also show that the said criteria is satisfied by orderings such as *lexicographic*, *degree lexicographic* and *weighted* orderings.

B12] Clique number of a graph with respect to idempotents of a ring

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Let R be a ring with nonzero identity. A simple graph $G_{Id}(R)$ is called a graph with respect to idempotents of R if its vertex set is the ring R and two distinct vertices x and y are adjacent if $(x+y)^2 = x+y$. The aim of this paper is to show that the graph $G_{Id}(R)$ is weakly perfect. We also proved that for finite rings complement of $G_{Id}(R)$ is connected.

B13] Symmetry-adapted lie algebraic approach to vibrational frequencies of OCS and HCP molecules

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This research article presents an exhaustive vibrational frequency analysis of OCS and HCP up to the fifth overtone, with a particular focus on exploring combinational bands. Utilizing Hamiltonian operator formalism alongside invariant operators and algebraic parameters through the one-dimensional Lie algebraic method, this approach provides a nuanced understanding of the vibrational modes inherent in OCS and HCP. The investigation unveils higher-order vibrational phenomena, often neglected in traditional spectroscopy, thereby elucidating intricate interplays among diverse vibrational modes. These newfound insights carry significant implications for atmospheric chemistry, spectroscopy, and quantum chemistry, contributing to an enhanced understanding of the molecular dynamics of OCS and HCP. Moreover, this study lays the groundwork for further exploration of analogous compounds and their applications.

B14] Some remarks on two-periodic modules over local rings

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We study some properties of finitely generated two-periodic modules over commutative Noetherian local rings. Under certain assumptions on a pair of modules (M, N) over a ring R, with M being two-periodic, we prove that the natural map $M \otimes_R N \to Hom_R(M^*, N)$ is an isomorphism. As a consequence, we have that the Auslander's depth formula holds for such a pair. Celikbas et al. recently showed that the Huneke-Wiegand conjecture holds over one-dimensional domain for two-periodic modules. We generalize their result to the case of two-periodic module with rank over any one-dimensional local ring. More generally, under certain assumptions on the modules, we show that a pair of modules over an one-dimensional local ring has non-zero torsion if and only if they are Tor-independent.

B15] Zero neighborhood absorbing hyperideals of hypernearring

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Algebraic hyperstructures generalize the classical algebraic structures like groups, rings and near-rings. Krasner introduced a class of hyperrings with addition being a hyperoperation and multiplication being a binary operation. It was found that the quotient structure loses its hyper-characteristics in the case of Krasner's hypernearring if the classical definition of an ideal is used. To overcome this problem, recently the notion of Zero Neighborhood Absorbing Hypernearing was introduced, with addition being the only hyperoperation. We study this structure in a more general form by taking all the operations involved as hyperoperations. Then we introduce the concept of zero neighborhood absorbing hyperideal. We find that the quotient structure induced by this hyperideal retains the hypercharacteristics. If $\{0\}$ is a zero neighborhood absorbing hyperideal, we call the hypernearring as general zero neighborhood absorbing (GZNA)-hypernearring. Formally, by a GZNA-hypernearring $(H, +, \cdot)$ we mean a quasicannonical hypergroup $(H, +)$ and a semihypergroup $(H, \cdot)$ satisfying the right distributive law and $h \cdot h' - h \cdot h' = \{0\}$. We present several properties of GZNA-hypernearring such as Peirce decomposition and derive isomorphism theorems.

B16] In the class of finite dismantlable lattices characterizations of modularity

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In this paper, modularity, distributivity and semimodularity are characterized in the class of finite dismantlable lattices using the concept of adjunct of chains.

B17] A study on cyclic and negacyclic codes with small Hermitian hull

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Linear codes with small dimensional hulls have attracted much interest among researchers recently. Here, we study the Hermitian hull of cyclic and negacyclcic codes. To be precise, we show the existence of cyclic and negacyclcic codes that have one-dimensional Hermitian hull. Further, we give sufficient conditions for one-dimensional linear complementary pairs of cyclic and negacyclcic codes.

B19] Normality theorem for elementary symplectic groups

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A.A. Suslin proved a normality theorem for an elementary linear group, which says that an elementary linear group of size bigger than or equal to 3 over a commutative ring with unity is normal in the general linear group of the same size. Subsequently, V.I. Kopeiko extended this result of Suslin for a symplectic group defined with respect to the standard skew-symmetric matrix of even size. Here we generalise the result of Kopeiko for a symplectic group defined with respect to any invertible skew-symmetric matrix of Pfaffian one.

B22] Heronian elliptic curves

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Identifying integers which occur as the area of a Heron triangle (rational triangle) with a specific angle is a generalization of the celebrated congruent number problem. This problem is equivalent to studying the rank of elliptic curves associated with Heron triangles. We discuss a large class of such elliptic curves. This talk will be based on the joint work with Debopam Chakraborty and Anupam Saikia.

B24] A note on a class of permutation trinomials

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Permutation polynomials are an interesting subject of mathematics and have applications in other areas of mathematics and engineering. Let $\mathbb{F}_q$ denote the finite field with q elements, where q is a prime power. In this paper, we investigate the trinomial $f(x) = x^{4q+1} + \alpha x^{5q} + x^{q+4}$ over the finite field $\mathbb{F}_{5^{2k}}$, where $\alpha \in \mathbb{F}_{5^k}^*$ with k being a positive integer. More precisely, We prove that the trinomial $f(x)$ is a permutation polynomial of $\mathbb{F}_{5^{2k}}$ if and only if $\alpha = -1$ and k is even. This work is a continuation of the previous work of Bai and Xia.

B25] Extension theory for non abelian Lie rings

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The primary objective of this paper is to develop an extension theory for non-abelian Lie rings. We establish a fundamental result concerning central extensions of non-abelian Lie rings. Specifically, we demonstrate one-to-one correspondence between the equivalence classes of central extensions of the Lie ring A by L and the elements of $H^2(L, Z(A))$, where L acts on the non-abelian Lie ring A. We also prove that if A is a trivial L-module, then this group is isomorphic to the direct product of the second cohomology group $H^2(L, Z(A))$ of groups and $Hom(\wedge^2 L, Z(A))$. Additionally, we address the problem of whether, given two Lie rings L and A and a Lie ring homomorphism $\Phi : L ß Out Der(A)$, there exists a Lie ring extension of A by L that induces the map Φ. To answer this problem, we obtain an obstruction $(\chi, \theta_1, \theta_2, \psi)$ to the 2-cocycle (f, g) being a factor system associated with an abstract kernel Φ. We establish necessary and sufficient conditions for the existence of such an extension. In other words, we prove that if the obstruction is zero, then the abstract kernel can be realized by an extension.

B26] h-EXTRA r-COMPONENT CONNECTIVITY OF 3-ARY n-CUBES

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The k-ary n-cube, denoted as Q_n^k, is one of the important interconnection networks for parallel and distributed computing systems. In this paper, we investigate the fault-tolerant capabilities of 3-ary n-cubes with respect to the extra connectivity and the component connectivity. Let G be a connected graph. For integers $h \geq 0$ and $r \geq 2$, an h-extra r-component cut is a subset F of $V(G)$ such that $G - F$ results in a disconnected graph with at least r components and each component contains more than h vertices. The h-extra r-component connectivity of G, denoted by $c\kappa_r^h(G)$, is the minimum size of an h-extra r-component cut of G. This paper determines the h-extra r-component connectivity of 3-ary n-cube when $h = 1$ and $r = 3$. For $n \geq 3$, $c\kappa_3^1(Q_n^3)$ is $8n - 11$.

B7P] Maximal and minimal pseudo symmetric ideals in partially ordered ternary semigroups

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We have introduced the notions of maximal and minimal pseudo symmetric ideals of a partially ordered ternary semigroup T and studied their properties. We show that every maximal pseudo symmetric ideal of a commutative partially ordered ternary semigroup with identity is a prime pseudo symmetric ideal. We gave an example to show that the converse of this statement is not true.

Section C : Real and Complex Analysis and Teaching of Mathematics

C2] On Nabla Shehu Transform For Time Scales With Applications

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Integral transform on time scales is a mathematical technique used to analyze functions on time scales, that combine continuous and discrete components. Due to some obstruction regarding calculus on the time scales under consideration, the nabla version of integral transform is more acceptable. In this paper, we introduce the nabla-Shehu transform on time scales, which is a generalization of the nabla-Laplace transform and the nabla-Sumudu transform on time scales. The existence theorem, and some fundamental properties such as linearity, transform of derivative, transform of integral, and convolution theorem are proved. Further we find transform of fractional integral, Riemann-Liouville fractional derivative, Liouville-Caputo fractional derivative and $\nabla-$Mittag-Leffler function and use them to solve fractional dynamic equations in subsequent sections.

C3] A Note On The Left Local General Truncated M-fractional Derivative

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We introduce a new type of conformable fractional derivative, which generalizes the standard properties and results of the classical integer order calculus viz. the Rolle's theorem, the Mean Value Theorems, the inverse property, the fundamental theorem of calculus, the theorem of integration by parts and the Taylor's theorem with integral remainder. After this, the extant conformable fractional derivatives are shown as the special cases of the new one. At the end, the well known Bernoulli's differential equation is generalized in terms of our newly defined fractional derivative. Also, some well known physical problems like Newton's law of cooling and Kirchhoff's current law are generalized and solved in terms of the conformable fractional sense and the importance of this newly defined operator with respect to the flexibility in the parametric values is described via the comparison of the solutions in the graphs using MATLAB software. At last, the image processing has been done with the aid of our newly defined fractional derivative operator.

C4] Certain Properties Of Functions Of Bounded Fractional Differential Variation

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In this paper, authors introduced several properties of functions of bounded fractional differential variation defined on closed intervals in $\mathbf{R}$ by using Caputo fractional derivatives instead of the commonly used first order derivatives. The structure and related results for class of functions of bounded fractional differential variation on closed intervals has also been discussed.

C5] On Some Inequalities Concerning The Polar Derivative Of A Polynomial

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In this paper, we establish some inequalities concerning to polar derivative of polynomial having all its zeros inside or outside a unit circle and thereby present some compact generalizations of certain well-known polynomial inequalities.

C7] Properties Of Bilateral Mock Theta Functions Of Order "Seventeen"

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Bilateral mock theta functions of order seventeen were obtained and studied by Mohammad Ahmad and Sirazul Haq .We express them in terms of Leach's transcendental function $f(x, \xi; q, p)$. We also express some bilateral mock theta functions as sum of other mock theta functions. We generalize these functions and show that these generalizations are F_q functions. We give an integral representation for these generalized functions.

C8] Uniqueness And Value Sharing Sets Of L-functions And Meromorphic Function

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In this literature survey, we study the uniqueness and value sharing sets of L-function and Meromorphic function. We pivot on sharing of two sets, one set with weight one and another set IM. We also have thought-about the case of sharing only one set with weight one. The impact of this paper come around the modernistic results due to Pulak Sahoo and Anjan Sarkar.

C9] Matrix Analogue Of Jacobi Polynomials

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This paper entitled "Matrix Analogue of Jacobi Polynomials" contains matrix analogue of Jacobi polynomials of one variable and of two variables. In this paper, we will talk about Jacobi polynomials of one variable along with its definition, matrix differential equation, Rodrigues formula, orthogonality, three-term recurrence formula and recurrence relations. Also, we will discuss about Jacobi polynomials of two variables with its definition in equivalent forms and integral representations, some relationships and particular cases.

C10] Forcing Relations On Orbit Patterns

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We extend the concept of orbit patterns for real dynamical systems from the notion of cyclic patterns, using the order relation inherited from the real line. The idea of orbit patterns encapsulates an orbit's combinatorial complexity. In the study of forcing relations among orbit patterns, we obtained that:

1. There are only 15 orbit patterns, which force only finitely many orbit patterns. 2. All simple cyclic patterns force only countably many orbit patterns. 3. All non-simple cyclic patterns force uncountably many orbit patterns.This line of thinking opens up a lot of problems to solve. For example, 1. Which orbit patterns force only countably many orbit patterns? 2. Which orbit patterns force uncountably many orbit patterns? More generally, which orbit patterns force which others?

C11] Approximation Of Signals Belonging To Certain Lipschitz Class Via Product Summability Means Of Its Conjugate Fourier Series

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The degree of approximation of Fourier series and conjugate Fourier series for Lipschitz classes of functions play an important role in the study of approximation theory as well as summability theory. Recently dealing with the degree of approximation of Fourier series of a signal (function) belonging to Lipchitz class Nigam *et al.* (Int. J. Pure Appl. Math., 82, 365–375) and Padhy *et al.* (Int. J. Math. Comp., 29, 71–78) have established certain theorems. Extending their results in this paper, we have established and proved a new theorem based on the degree of approximation of a signal (function) $f \in Lip(\xi(t), r)$ via the $(E, q)A$ product summability means of conjugate Fourier series.

C12] On Statistical Euler Summability Methods For Sequences Of Fuzzy Numbers And Its Applications To Fuzzy Korovkin's Theory

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The concept of statistical convergence has attracted the pervasive attention of the current researchers due basically to the fact that it is stronger than the ordinary convergence. Korovkin-type approximation theorem plays a vital role in the convergence of sequences of positive linear operators. Moreover, this type of approximation theorems has been extended through different statistical summability methods over general sequence spaces. In this proposed paper, we have introduced a new statistical Euler summability mean for sequences of fuzzy numbers and accordingly proved a fuzzy Korovkin-type approximation theorem. Furthermore, we have established another result for the fuzzy rate of convergence which is uniform in fuzzy Korovkin-type approximation theorem under our proposed summability mean.

C15] q-Laguerre Polynomial In Two Variables

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The main objective of this article is to discuss q-Laguerre polynomials in two variables $L_n^{(\alpha,\beta)}(x, y; q)$. We also give some properties: generating functions, integral representation, recurrence relation, finite sum property, etc.

C16] Bessel And Flett Potential Associated With $(k, 1)$-Generalized Fourier Transform

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In this article, we introduce the Bessel and Flett potentials for the $(k, 1)$-generalized Fourier transform. We show that the $(k, 1)$- Fourier-Bessel potentials of positive order can be represented by an integral involving (k,1)-heat transform and deduce some of its properties. Further, we obtain an explicit inversion formula for $(k, 1)$-Fourier-Flett potentials.

C17] Results on transcendental meromorphic function of Finite order on fixed points of difference polynomials

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In this paper, we investigate $f(z)$ to be a transcendental meromorphic function of finite order $\sigma(f)$ and $c \in C$ be complex constants. Here we mainly concentrated on establishing a fixed points about the difference polynomials $\Phi(z) = \Delta f(z) - a(f(z))^n$, where $\Delta f(z) = f(z+c) - f(z)$. These results are extend the related results obtained by Zhaojun Wu and Jia Wu.

Section D : Functional Analysis, Measure Theory, Probability Theory, Stochastic Processes and Information Theory

D2] Self-adaptive accelerated method for approximating the solution of split best proximity point problem and mixed equilibrium problem

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The primary goal of this paper is to present and study a self-adaptive accelerated algorithm for solving the split best proximity point problem and mixed equilibrium problem. We find a solution of the best proximity point problem in such a way that its image under a bounded linear operator is the solution of mixed equilibrium problem in the setting of real Hilbert spaces. We construct an iterative algorithm for the proposed problem and prove a weak convergence theorem. Moreover, we deduce some consequences from main convergence result. Finally, a numerical experiment is also presented to demonstrate the convergence analysis of our algorithm. The methodology and results presented in this work improve and unify some previously published findings in this field.

D4] Compact Elements in the Weighted Discrete Abelian Semigroup Algebra $l^1(S, \omega)$

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Let $\mathcal{A}$ be a Banach algebra and $a \in \mathcal{A}$. Define the bounded linear operator L_a on $\mathcal{A}$ as $L_a(x) = ax \ \ (x \in \mathcal{A})$. If the operator L_a is compact, then a is called a *compact element* in $\mathcal{A}$. The compact elements of the convolution Banach algebra $L^1(\mathbb{R}_+, \omega)$ have been extensively studied by Bade and Dales, and for the weighted discrete semigroup algebra $l^1(S, \omega)$ by Grønbæk and Dedania. The objective of this presentation is twofold. First is to prove the weighted discrete analogues of some results proved on the compact elements in $L^1(\mathbb{R}_+, \omega)$. Second is to set the record right by correcting some results proved in the Ph.D. Thesis of Grønbæk.

D5] Continuity of the Approximate Pseudospectrum

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Let $B(X)$ be the space of all bounded linear operators acting on a complex Banach space X and $\mathbb{C}$ denotes the set of complex numbers. If $T \in B(X)$ and $\varepsilon > 0$ then the approximate pseudospectrum is defined as $\Sigma_{ap,\varepsilon}(T) = \sigma_{ap}(T) \cup \left\{\lambda \in \mathbb{C} : \inf_{\|x\|=1} \|(T-\lambda)x\| \leq \varepsilon\right\}$ where $\sigma_{ap}(T) = \left\{\lambda \in \mathbb{C} : \inf_{\|x\|=1} \|(T-\lambda)x\| = 0\right\}$. We define the following correspondances (set valued maps)

$$\mathcal{APE} : \mathbb{R}^+ \twoheadrightarrow \mathbb{C} \text{ defined by } \mathcal{APE}(\varepsilon) = \Sigma_{ap,\varepsilon}(T) \text{ for fixed } T \in B(X)$$

$$\mathcal{AP} : B(X) \twoheadrightarrow \mathbb{C} \text{ defined by } \mathcal{AP}(T) = \Sigma_{ap,\varepsilon}(T) \text{ for fixed } \varepsilon \in \mathbb{R}^+$$

and

$$\mathcal{APS} : \mathbb{R}^+ \times B(X) \twoheadrightarrow \mathbb{C} \text{ defined by } \mathcal{APS}(\varepsilon, T) = \Sigma_{ap,\varepsilon}(T).$$

We investigate about the continuity nature of the above defined correspondences. We see that the correspondences $\mathcal{APE}$, $\mathcal{AP}$ and $\mathcal{APS}$ are the upper hemicontinuous but not the lower hemicontinuous in general. Examples were constructed to show the light on the established results.

D6] System of Generalized mixed equilibrium problems and hierarchical fixed point problems

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In this paper, we investigate a hybrid extra-gradient iterative method to approximate the common solution of a system of unrelated generalized mixed equilibrium problems for monotone and Lipschitz continuous mappings and system of unrelated hierarchical fixed point problems for nonexpansive mappings in Hilbert space. We prove a strong convergence theorem for the sequences generated by the proposed iterative algorithm. Further, we give some consequences and applications of our main result. Finally, we discuss a numerical example to demonstrate the applicability of the iterative algorithm. The method and results presented in this paper extend and unify the corresponding known results of this area.

D9] Approximate Solutions of Generalized Cayley operator with applications to Cayley inclusions

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In this paper, we present a generalized Cayley operator and a generalized Cayley inclusion problem (GCIP). A fixed point formulation of (GCIP) is established and using this an iterative algorithm is developed to show the existence and convergence of the solutions of (GCIP). We also establish the equivalence of the (GCIP) and generalized resolvent equation problem (GCEP), and develop an iterative algorithm and some of its equivalent forms to approximate the solution of (GCEP). To support our results, we construct a numerical example and convergence graphs using MATLAB programming.

D10] Spaces of Analytic Functions and Weighted Composition operators

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Let $H(\mathcal{D})$ denote the space of complex-valued holomorphic functions on the unit disk $\mathcal{D}$ in the complex plane $\mathcal{C}$. For two given functions, φ and ψ, both elements of $H(\mathcal{D})$ and satisfying the condition $\varphi(\mathcal{D}) \subseteq \mathcal{D}$, we introduce the concept of a weighted composition operator, denoted as $W_{\varphi,\psi}$, which acts on the function space $H(\mathcal{D})$ and is defined as

$$W_{\varphi,\psi}(f)(z) = \psi(z)f(\varphi(z)).$$

In the special case where ψ is constantly equal to 1, we obtain the familiar composition operator C_φ, given by

$$C_\varphi(f) = f \circ \varphi.$$

Similarly, if φ is the identity function ($\varphi \equiv I$), we arrive at the multiplication operator M_ψ defined as $M_\psi(f)(z) = \psi(z)f(z)$. We introduce two distinct Lebesgue area measures: the normalized Lebesgue area measure, denoted as $dA(z)$ and equal to $\frac{1}{\pi}dxdy$, and the weighted Lebesgue area measure, denoted as $dA_\alpha(z) = (1+\alpha)(1-|z|^2)^\alpha dA(z)$, which is characterized by the parameter α. For functions in the Dirichlet-type spaces, denoted as $\mathcal{D}^p_\alpha$, where $0 < p < \infty$ and $-1 < \alpha < \infty$. We define a norm

$$\|f\|_{\mathcal{D}^p_\alpha} = \left(|f(0)|^p + \int_{\mathcal{D}} |f'(z)|^p dA_\alpha(z)\right)^{1/p} < \infty.$$

Additionally, we introduce Q_α, a Banach space comprised of functions $f \in \mathcal{D}^2_\alpha$, with its own norm defined as

$$\|f\|_{Q_\alpha = |f(0)| + \sup_{\omega\in\mathcal{D}} \|f\circ\varphi_\omega - f\|_{\mathcal{D}^2_\alpha} < \infty},$$

where $\varphi_\omega = \frac{\omega - z}{1-\bar{\omega}z}$.

In our research, we delve into characterizing the boundedness and compactness of weighted composition operators that operate between different spaces of holomorphic functions. Our approach leverages the Carleson measure technique to provide insights and findings regarding the essential norm estimates for these operators.

D11] General shift invariant systems and Gabor frames over irregular lattices in local fields of positive characteristic

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In this paper, we have discussed some necessary and sufficient conditions for dual frames formed by shift invariant systems which are also Bessel sequences. Further, explicit expression for Walnut operator associated with window function of Gabor frames in local fields of positive characteristics is given. Also properties of Gabor frames over irregular lattices in local fields of positive characteristics are discussed.

D12] λ-limited sets in Banach spaces

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In this work, we introduce the concept of λ-limited sets in a Banach space X using the vector valued sequence spaces $\lambda^{w^*}(X^*)$. We show that the class of λ-limited operators is an operator ideal containing the ideal of λ-compact operators for a suitably restricted λ. We also investigate the relation between absolutely λ-summing and λ-limited operators. Furthermore, we define generalised Gelfand-Philips property for Banach spaces corresponding to an abstract sequence space λ.

D13] Besov and Triebel-Lizorkin Capacity in Metric Spaces

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We prove a lower bound estimate for Hajłasz-Besov capacity in metric spaces in terms of Netrusov-Hausdorff content. We also prove a similar estimate for Hajłasz-Triebel-Lizorkin capacity in terms of Hausdorff content. These results are improvements of the earlier results obtained by Nuutinen in 2016 and the first author in 2020. In this paper, we study the relation between the Hajłasz-Besov capacity and Netrusov content as well as the relation between Hajłasz-Triebel-Lizorkin capacity and Hausdorff content in metric spaces. In metric spaces, the capacities are based on the pointwise definitions of Besov spaces and Triebel-Lizorkin spaces which was introduced earlier. These spaces are generalized from Hajłasz-Sobolev space $M^{s,p}(X)$ and are widely known as Hajłasz-Besov space $N^s_{p,q}(X)$ and Hajłasz-Triebel-Lizorkin space $M^s_{p,q}(X)$, where $X = (X, d, \mu)$ is a metric measure space.

D14] Boundedness of the Localization Operator

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In this paper, we study a class of operators named time-frequency localization operators on sequence spaces that are defined over a lattice. We validate the boundedness and Schatten class properties of the localization operators by taking the symbol function η and window function g_1 and g_2 from Modulation spaces and Lebesgue spaces.

Section E : Differential / Integral and Functional Equations

E2] Existence of Multiple Unbounded Solutions for a Three-Point Boundary Value Problems on an Infinite Time Scales

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We consider the second order three point boundary value problem on time scales ($\mathbb{T}$) with integral boundary conditions on the half-line

$$u^{\Delta\Delta}(t) + q(t)f(t, u(t), u^{\Delta}(t)) = 0, \quad t \in (0, \infty)_{\mathbb{T}},$$

$$u(0) - au^{\Delta}(0) = \lambda \int_0^{\eta} u(s)\Delta s,$$

$$\lim_{t\to+\infty} u^{\Delta}(t) = u^{\Delta}(\infty) = \lambda \int_0^{\eta} u(s)\Delta s,$$

where $\lambda > 0$, $0 < \lambda\eta < 1$, $a > 0$, $q : (0, \infty)_{\mathbb{T}} \to (0, \infty)_{\mathbb{T}}$, $f : [0, +\infty)_{\mathbb{T}} \times \mathbb{R} \times \mathbb{R} \to \mathbb{R}$ is continuous and satisfies Nagumo's condition. We will use the upper and lower solution method along with the Schauder's fixede point theorem to establish the existence of at least one solution which lies between pairs of unbounded upper and lower solutions. Further, by assuming two pairs of unbounded upper and lower solutions, the Nagumo's condition on the nonlinear term involved in the first -order derivative, we will establish the existence of multiple unbounded solutions on an infinite interval by using the topological degree theory.

E3] Approximation of solutions to abstract neutral impulsive differential equations

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In this manuscript, we consider a class of first order abstract neutral differential equations with non-instantaneous impulses in an arbitrary separable Hilbert space and study the approximation of solutions. In order to define approximation, we use a projection scheme. We establish the existence of approximate solutions by using the Banach fixed point method and analytic semigroup theory. Further, we show that with respect to a suitable norm these approximate solutions form a Cauchy sequence and converge to the solution of the original problem. Also, we study the Faedo-Galerkin approximate solutions and their convergence to the solution of our given problem. At last, an example involving partial differential equation is presented for illustrating the discussed abstract results.

E4] The study of inverse problem for abstract fractional differential equation

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Inverse problems are the most important mathematical problems in science and mathematics because they provide information about factors that are difficult to study directly. In particularly, inverse problems for abstract fractional differential equations are essential for the accurate modeling and simulation of fractional systems, which have been found to have applications in various areas. The main focus of this talk is to discuss an inverse problem of fractional order $0 < \alpha < 1$ in a Banach space by two approaches: one is for regular data and another is for irregular data. For regular data, we use the direct approach using Volterra integral equation and for irregular data, we use an optimal control approach using Euler-Lagrange equations for fractional optimal control problem and shifted Legendre polynomials. Additionally, we shed some light on the different types of analytic and numerical techniques to solve an inverse problem for abstract differential equations.

E5] On the system of nonlinear Volterra integral equation in two variables on time scales

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In this paper, an attempt has been made to establish the existence and uniqueness properties of solutions of the following nonlinear Volterra integral equation in two variables on time scales

$$u(x,y) = f(x,y) + \int_0^x g(t,s,\xi,u(\xi,y))\Delta\xi + \int_0^x \int_0^y h(t,s,\sigma,\tau,u(\sigma,\tau))\Delta\tau\Delta\sigma,$$

for $(x,y) \in E = I_{\mathbb{T}} \times I_{\mathbb{T}}$, $I_{\mathbb{T}} = [0,\infty) \cap \mathbb{T}$ and $\mathbb{T}$ is an arbitrary time scale, $E_1 = \{(x,y,s) : 0 \leq s \leq x < \infty, y \in I_{\mathbb{T}}\}$ and $E_2 = \{(x,y,s,t) : 0 \leq s \leq x < \infty, 0 \leq t \leq y < \infty\}$, where $f \in C_{rd}(E,\mathbb{R}^n)$ and $g \in C_{rd}(E_1 \times \mathbb{R}^n, \mathbb{R}^n)$ and $h \in C_{rd}(E_2 \times \mathbb{R}^n, \mathbb{R}^n)$, by using Banach fixed point theorem and a well-known established integral inequality with explicit estimate on unknown function. Examples are given to justify the established results.

E6] Controllability of a second-order non-autonomous stochastic semilinear system with several delays in control

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We study a second-order non-autonomous semilinear stochastic system with several constant point delays in control. We prove the existence and uniqueness of mild solution using the semigroup theory of bounded linear operators, evolution family, stochastic analysis techniques, and Banach contraction principle. Our goal is to discuss the various types of controllability of the semilinear system. In the end, an example is included as an application to demonstrate the result.
The mathematical model of the considered problem is as follows:

$$\begin{cases} \frac{d^2z(t)}{dt^2} = A(t)z(t) + \sum_{i=0}^{n} B_i u(t-\eta_i) + f\big(t, z(t), u(t), u(t-\eta_1), \ldots, u(t-\eta_n)\big) \\ \qquad\qquad +g\big(t, z(t), u(t), u(t-\eta_1), \ldots, u(t-\eta_n)\big)\frac{dw(t)}{dt}, \quad t \in J = [0,T], \\ z(0) = z_0, \quad z'(0) = z_1, \\ u(t) = 0, \quad t \in [-\eta_n, 0]. \end{cases}$$

Let Z, W and U be real separable Hilbert spaces and $A(t) : D(A)(t) \subseteq Z \to Z$ generates a strongly continuous semigroup of bounded linear operators. The control function $u(\cdot)$ belongs to the set of admissible control functions $U_{ad} = L^p_\Upsilon(J, U)$, which is closed and convex and $B_1, B_2, \ldots, B_n \in L(U, Z)$ are linear continuous operators. Here, w is a W-valued Q-Wiener process on the complete probability space $(\Omega, \Upsilon, \Upsilon_t, P)$ with the usual conditions. Moreover, f and g are some appropriate functions and $0 = \eta_0 < \eta_1 < \eta_2 < \cdots < \eta_n$ are constant point delays.

E7] Dynamical System for Sum of Zeros of Operators and Fixed Point Problems

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In this paper, we propose a dynamical system for finding an element of the set $\Omega := \mathrm{Fix}(T) \cap (P + Q)^{-1}(0)$, where $\mathrm{Fix}(T)$ is the set of fixed points of a nonexpansive mapping T defined on a closed convex subset K of a Hilbert space H into itself, $P : K \to H$ is an α-inverse strongly monotone mapping of K into H and Q be a maximal monotone operator on H such that the domain of Q is included in K. Further, we consider the problem for finding a common element of the set of solutions of an equilibrium problem and the set of fixed points of a nonexpansive mapping. The weak convergence of the trajectories obtained by the proposed dynamical systems is studied. The proposed dynamical systems and their convergence are demonstrated by numerical examples.

E9] Positive solution for a class of singular fractional boundary value problem with p-Laplacian

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In this paper, an attempt has been made to establish the sufficient conditions for the existence and multiplicity of positive solutions by using the fixed point index theory and Avery-Peterson fixed point theorem respectively for the following class of nonlinear singular fractional differential equation

$$D^{\beta}_{0^+}(\phi_p(D^{\alpha}_{0^+}u(t))) + f(t, u(t), \ldots, u^{(n-2)}(t)) = 0, \quad t \in (0,1),$$

with the boundary condition,

$$u^{(k)}(0) = 0, 0 \leq k \leq n-2, D^{\alpha}_{0^+}u(0) = 0, D^{\alpha-1}_{0^+}u(1) = \int_0^1 D^{\alpha-1}_{0^+}u(t)dA(t),$$

where, $0 < \beta \leq 1, n-1 < \alpha \leq n, n \geq 3, A : [0,1] \to \mathbb{R}$ is a function of bounded variation, $\phi_p(s) = |s|^{p-2}s$ for $p \geq 2$ and $\phi_q(s)$ is the inverse of $\phi_p(s)$, where p, q satisfies the relation $\frac{1}{p} + \frac{1}{q} = 1$, f may be singular at $t = 0$.

E10] Analysis of (2+1)-dimensional two-phase mass flow model using a two-dimensional optimal system of Lie algebras

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The paper investigates a two-phase mass flow model governed by gravity, involving solid particles and a viscous fluid. By utilizing the Lie symmetries admitted by the system, similarity solutions for the (2+1)-dimensional two-phase mass flow model are obtained. A comprehensive set of local point symmetries is established, and a well-suited collection of two-dimensional subalgebras is constructed from the maximal Lie invariance algebra. The optimal system's vector fields are then utilized to directly reduce the governing model to a system of ordinary differential equations. Through analytical solutions, we successfully solve the resulting systems and further analyze their physical behaviors numerically.

E11] Stability Analysis Of System Of Additive Functional Equations From A Hotel Model

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In this paper, the author establish the Generalized Ulam - Hyers stability of system of additive functional equations from a hotel model in Banach Space via classical Hyers Method.

E12] Ulam - Hyers Stability of Euler - Lagrange sextic Functional Equation in Intuitionistic Fuzzy Banach Spaces: Direct and Fixed Point Methods

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In this paper, authors verify the generalized Ulam - Hyers stability of the Euler - Lagrange sextic functional equation in Intuitionistic Fuzzy Banach Spaces using direct and fixed point methods.

E13] Fuzzy Stability of a Generalized Quadratic Functional Equation

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In this paper, we prove the Ulam Hyers stability of a generalized quadratic functional equation

$$q(v+\eta w) - 2q(v+(\eta-1)w) + q(v+(\eta-2)w) = 2!\ q(w)$$

where $\eta \geq 1$ in Fuzzy Banach space in two different methods.

E14] Modular Stability of a Functional equation originating from sum of first l natural numbers.

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In this paper, the authors analyze the generalized Ulam - Hyers stability of a functional equation

$$f\left(\sum_{j=1}^{\ell} j\ w_j\right) = \sum_{j=1}^{\ell} (j\ f(w_j)), \qquad \ell \geq 1$$

which is originating from sum of first ℓ natural numbers in Modular space.

E15] Miscible Flows in Heterogeneous Porous Media Based On Darcy-Stokes-Brinkman Model: Existence and Uniqueness

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Vuggy porous media are encountered in various physical phenomena, such as oil and gas reservoirs, aquifer studies, and contaminant transport. Traditionally, the flow in vuggy porous media has been modeled by applying Stokes and Darcy laws in the vugs and porous regions, respectively. These equations are then interconnected through interfacial conditions such as the Beavers-Joseph (BJ) conditions. Numerical handling of such a two-domain problem is highly non-trivial, and the computation cost is huge. Recently, it has been proposed to use the Brinkman equation as a single equation in the entire domain for such flow problems. By appropriately non-dimensionalizing the Brinkman model, we can effectively recover the problems described by Stokes and Darcy's equations.

This study explores a fluid model that couples a convection-diffusion equation for solute concentration with an unsteady Brinkman equation for the flow field, including Korteweg stress. Additionally, since vuggy porous media are naturally heterogeneous, we account for this heterogeneity by treating permeability as a function of fluid concentration. Due to the presence of non-linearities, it is extremely hard to explore analytical solutions. Therefore, most studies focus on the numerical investigation of these models. However, we discuss theoretical analysis using a variational approach. Specifically, the study proves the existence and uniqueness of weak solutions to this problem by employing the regularized Galerkin method and hemivariational inequalities.

E16] RB Stability of a Mixed Additive Quadratic Functional Equation

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In this paper, we establish the stability of a mixed additive quadratic functional equation

$$f(2x_1 + x_2) - f(2x_1 - x_2) = 2[f(x_1 + x_2) - f(x_1 - x_2)] - f(x_2) + f(-x_2)$$

in RB space using two methods.

E17] Approximate analytical method for hyperbolic system of partial differential equations

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The proposed work focuses on the study of homotopy-based approximate analytical techniques for evaluating partial differential equations(PDEs) with continuous and piece-wise initial conditions. The well-proposed homotopy analysis method (HAM) is taken into consideration. The approximate method based on a zeroth-order deformation equations in topology contains the auxiliary operator for mapping an initial estimation to the unknown solution and ensures rapid convergence of the given series approximate solution. Implementation of residual error through algebraic equations depicts that the proposed zero-order deformation equation essentially increases the rate of the convergence region and series solution and concedes greater freedom in the choosing of convergence operators than the traditional approximate methods. As a starting point of approach, we applied HAM to a linear system of PDEs in the first-order form with prescribed conditions, including the presence and absence of governing parameters. The convergence of the system of PDEs is analysed through auxiliary parameter value. The derived series solution obtained from HAM is compared with an exact solution in order to confirm accuracy and effectiveness. The HAM series shows more rapid convergence than the usual numerical and approximate approach and confirms accuracy in comparison with an exact solution in the limiting case. The work proposed in this thesis has a basis in practice, and, in each case, definitive and existing results have been obtained, which are believed to be useful for engineering practice.

E18] Oscillation of two-dimensional nonlinear neutral delay differential systems

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In this work, necessary and sufficient conditions of two-dimensional nonlinear neutral delay differential systems are obtained such that every vector solutions of

$$\frac{d}{dt}\begin{bmatrix} u(t)-p(t)u(t-\tau) \\ v(t)-p(t)v(t-\tau) \end{bmatrix} = \begin{bmatrix} a(t) & b(t) \\ c(t) & d(t) \end{bmatrix} \begin{bmatrix} f_1(u(t-\alpha)) \\ f_2(v(t-\beta)) \end{bmatrix}$$

are oscillatory or tends to zero as $t \to \infty$, where $p, a, b, c, d, f_1, f_2 \in C(\mathbb{R}, \mathbb{R}); \alpha, \beta, \tau \in \mathbb{R}^+$ with $sf_1(s) > 0$ and $sf_2(s) > 0$ for $s \neq 0$. Different ranges for $p(t)$ are considered. For the existence of nonoscillatory solution, Krasnoselskii's fixed point theorem is used.

E19] Oscillation of First Order Nonlinear Systems of Delay Difference Equations

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This work is concerned with sufficient conditions for oscillation of all vector solutions of first order nonlinear systems of delay difference equations of the form:

$$\begin{bmatrix} r(m+1) \\ s(m+1) \end{bmatrix} = \begin{bmatrix} a_1(m) & a_2(m) \\ a_3(m) & a_4(m) \end{bmatrix} \begin{bmatrix} g(r(m-\delta)) \\ h(s(m-\eta)) \end{bmatrix}, m \geq m_0,$$

where $a_1(m), a_2(m), a_3(m)$, and $a_4(m)$ are sequences of real numbers. $\delta \geq 0, \eta \geq 0$ are integers and $m \in \mathbb{N}(m_0) = \{m_0, m_0+1, \cdots\}, m_0 \geq 0$ such that $a_1(m)a_4(m) - a_2(m)a_3(m) \neq 0$ and $g, h \in \mathcal{C}(\mathbb{R}, \mathbb{R})$ with $ug(u) > 0, uh(u) > 0$ for $u \neq 0$. We verify our results by some illustrative examples.

E20] Invariant solutions for generalized inhomogeneous-nonautonomous (2+1)-dimensional Konopelchenko Dubrovsky equation through Lie symmetry analysis.

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The (2+1)dimensional Konopelchenko Dubrovsky equation (2D-KDE) is a partial integro-differential equation (PIDE) which describes two-layer fluid in shallow water near ocean shores. At first, invariance criterion for 2D-KDE are found and hence four dimensional Lie- algebra is obtained. Further, two-dimensional optimal classification is carried out for four dimensional Lie algebra. Finally, invariant solution are obtained for each class of the optimal set by transforming integro-differential equation (IDE) with three independent variables to IDE with one independent variable.

E21] Iteration operator and its properties

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We discuss the iteration operator on the space of all self-maps on different metric spaces and characterize the fixed points and periodic points. Moreover, we explicitly identify the monotonic periodic points and fixed points of the iteration operator on an interval.

E23P] Similarity Solutions of a two-dimensional Riemann problem for a thin film model of a perfectly soluble antisurfactant solution

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This poster uses the Lie group of transformation with matching infinitesimal generators to analyze the similarity solutions of an antisurfactant solution in a two-dimensional thin film flow. The governing partial differential equations admit symmetry groups, these symmetry groups are obtained and establish the complete Lie algebra of infinitesimal symmetries. After constructing similarity variables with the use of symmetry generators, a system of ordinary differential equations is ultimately produced, which is a reduced system of equations with one fewer independent variable at a time. These equations can be solved exactly in some cases.

E24] Analytic solution of two dimensional problems of elasticity and thermoelasticity in an inhomogeneous strip.

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This paper presents an analytical approach for solving two-dimensional problems of elasticity and thermo-elasticity in terms of stresses in an inhomogeneous strip. We employed direct integration method for differential and compatibility equations for isotropic material. Reducing the governing equation to integro-differential equation. We have solved these dominant equations by applying Fourier transform.

E25] Solution of Schneider-Wyss fractional diffusion equation using Iterated method.

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In the present paper with the help of the most effective Variational Iterative method , the analytical solution of The Schneider -Wyss fractional diffusion equation is obtained. We introduce different cases for given initial conditions. The presented method can be illustrated with the use of some examples which shows the effectivenes and strength of the above illustrated method. The rate of convergence for the proposed method is established. Different particular cases of the examples of numerical results are presented graphically. A comparison of numerical results highlights the accuracy and efficiency of the provided scheme.

E27] Positive Solutions of the Discrete Fractional Oscillation Equation

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This article establishes sufficient conditions for the existence of positive solutions to the discrete fractional oscillation equation using the well-known conical shell fixed point theorem. Two numerical examples illustrate the applicability of the established results.

E28] Existence and uniqueness of solutions for a class of iterative differential equations with initial conditions

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The aim of the present paper is to establish the existence and uniqueness of solutions of iterative differential equations of the type $x'(t) = f\left(t, x^{[1]}(t), x^{[2]}(t), x^{[3]}(t), \cdots, x^{[n]}(t)\right)$ with initial condition $x(t_0) = x_0$.

E29] Some Novel Time-Scale Inequalities of Pachpatte Type for Dynamic Equations and Applications

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In this research, we introduce several unique delta-derivative-based dynamic inequalities on time scales. Certain previous disparities in the literature are improved and extended by these inequalities. These inequalities serve as useful tools for investigating both the qualitative and quantitative characteristics of class of time scale dynamic equations consisting of unknown function alongwith its delta derivatives.

E30] Analysis of Fractional Ordered Incommensurate Quadratic Jerk System

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Fractional ordered dynamical systems (FODS) are being studied in the present due to their innate qualitative and quantitative properties and their applications in various fields. The Jerk system, which is a system involving three differential equations with quadratic complexity, arises naturally in wide ranging fields, and hence a qualitative study of solutions of jerk system and its various parameters under different conditions is important. In this article, we have studied phenomena of the Hopf bifurcation and chaos occurring in fractional ordered commensurate and incommensurate quadratic jerk system. The equilibrium points of the system are obtained and are found to be $(\pm\epsilon, 0, 0)$, where ϵ denotes the system parameter versus which bifurcation is analyzed. We have presented the criteria for commensurate and incommensurate quadratic jerk system to undergo a Hopf bifurcation. The value of ϵ at which system undergoes Hopf bifurcation ϵ_H is obtained for both commensurate as well as incommensurate system. It is known that supercritical Hopf bifurcation leads to chaos. The obtained results are verified through numerical simulations versus the fractional order α and parameter ϵ and the explicit range in which the system exhibits chaos is found. A number of phase portraits, bifurcation diagrams, and Lyapunov exponent diagrams are presented to affirm the obtained chaotic range of parameters.

E31] Existence and Stability of ψ-Hilfer hybrid fractional differential equation with boundary conditions

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In this paper we discuss the existence and stability of hybrid fractional differential equations of first type involving $\psi-$Hilfer fractional derivative with boundary conditions, which is given by

$$\begin{cases} {}^{H}\mathbb{D}_{0+}^{\alpha,\beta;\psi} \frac{u(t)}{f(t,ut))} = g(t, u(t)), \quad a.e \quad t \in J = [0, T] \\ aI_{0+}^{1-\gamma,\psi} \frac{u(0)}{f(0,u(0)} + b\frac{u(T)}{f(T,u(T))} = c \end{cases}$$

where ${}^{H}\mathbb{D}^{\alpha,\beta;\psi}(\cdot)$ is the ψ-Hilfer fractional derivative with $0 < \alpha < 1, 0 \leq \beta \leq 1$, $\alpha \leq \gamma = \alpha + \beta - \alpha\beta < 1$ and $f \in C_{1-\gamma;\psi}(J \times \mathbb{R}, \mathbb{R}|\{0\})$, $g \in \mathcal{C}_{1-\gamma;\psi}(J \times \mathbb{R}, \mathbb{R})$ and a, b, c are real numbers with $b(\psi(T) - \psi(0)) \neq 0$. The existence is proved using Dhange's fixed point theorem. Also we prove different types of Ulam stability results of solution for the given boundary value problem.

E32] Existence, Uniqueness and Controllability results for Fractional Neutral Integro Differential Equations with Non-instantaneous impulses and delay

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In this paper, we prove the existence, uniqueness and controllability results for fractional neutral integro-differential equation and non-instantaneous impulses in Banach spaces. To obtain the existence and controllability results, we have enforced the concepts of fractional calculus and fixed point theorems. Examples are also given to illustrate the results.

E33] Ulam stability of general Euler - Lagrange Additive Functional Equation in Quasi Fuzzy β Normed Spaces

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In this paper, we investigate the Ulam stability of general Euler - Lagrange additive functional equation of the form

$$mkf(ax+by)+kbf\left(x-\left(\frac{ma}{kb}\right)y\right)=(ma+b)\,kf(x)-(a-kb)\,mf(y)$$

where $mk, kb \neq 0$ and $a, b, m, k \in R$ in Quasi Fuzzy β Normed Spaces.

E34] Using Novel Technique to Solve Fractional Differential Equations

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The use of fractional calculus may be seen all throughout the world. Fraction notions have been used in a wide range of physical processes in many different scientific areas, including engineering, physics, and chemistry, to name a few. There are several approaches that may be used, including the Fractional Calculus. Fractional Differential Equations (FDEs) have various applications in engineering, including fractional cross product, electronic circuits, control engineering, electronic system design, and speech modelling. We present a fractional order expressive finite difference technique for the time fractional wave equation in this study. We further show that the model is unconditionally stable and convergent. The numerical fix of the test issue is achieved using Python Programme and visually shown as a component of the scheme.

E35] Non-Homogeneous Fractional Differential Equation in Complex Domain

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In the sense of the Riemann-Liouville (R-L) fractional operators, this paper discusses an arbitrary-order $\delta = \tau + ia, 1 < \tau \leq 2, a \in \mathbb{R}^+$ non-homogeneous fractional differential equation (FDE) in the complex domain. The existence of holomorphic solutions is established in this study using the Power series method. We use analytic function theory and the Rouch´e-Frobenius theorem to identify conditions where holomorphic solutions exist uniquely in the complex domain.

Section F : Geometry and Topology

F1] On Gradient Ricci Soliton Space-Time Warped Product

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In this article, we introduce the notion of space-time warped product $\tilde{M} = (B \times I) \times_f F$ with potentially infinite metric $\tilde{g} = (g_B + (R + \frac{N}{2t})dt^2) + f^2 g_F$. First we find connection and Ricci curvatures of Space-time manifold, $(B \times I)\times, g_B + (R + \frac{N}{2t})dt^2)$. Then, we discuss Ricci curvature approximation upto $O(N^{-1})$ and potentially gradient Ricci soliton identities for space-time warped product. We also investigate the Deturck's trick and study Variation of metric $\tilde{g}$ on $(B \times I) \times_f F$. Next, we prove Existence conditions for the gradient Ricci soliton space-time warped product. For a compact base and fiber manifold of dimension at least two, we obtain several results for expanding or steady and shrinking gradient Ricci soliton $(\tilde{M}, \tilde{g}, \tilde{\nabla}\phi, \lambda)$. Further, we prove the compactness of space-time manifold, $B \times I$ when it satisfy some inequality. Finally, we give some examples of generalized black hole solutions whose metrics can be written as a space-time warped product metric.

F2] Semi-Slant Lightlike Submanifolds of Indefinite Sasakian Manifolds

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In this paper, we introduce the notion of semi-slant lightlike submanifolds of indefinite Sasakian manifolds giving characterization theorem with some non-trivial examples of such submanifolds. Integrability conditions of distributions D_1, D_2 and $RadTM$ on semi-slant lightlike submanifolds of an indefinite Sasakian manifold have been obtained. We also obtain necessary and sufficient conditions for foliations determined by above distributions to be totally geodesic.

F3] Quasi Bi-Slant Submanifolds of Locally Metallic Riemannian Manifolds

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In this article, we investigate quasi bi-slant submanifolds of locally metallic Riemannian manifolds. The main objective is to determine the conditions under which the distributions used in defining these submanifolds are integrable. We also establish the necessary and sufficient conditions for quasi bi-slant submanifold to be a totally geodesic foliation.

F4] Study on Intutionistic Fuzzy Hausdorff Bitopological Spaces: Theoretical Insights

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In contrast to classical set theory that assumes that an element either belongs to a set or does not, fuzzy sets enable the representation of partial membership within a set. The theory of intuitionistic fuzzy sets goes beyond conventional concepts by evaluating elements through two functions: one for membership and another for non-membership. These functions operate within the real unit interval [0, 1], and their combined sum remains within the same interval. In this document paper, we offer the concepts of some notions of Hausdorff (T_2) property in intuitionistic fuzzy bitopological spaces. We demonstrate that each of them notion satisfies good extension property. We also establish that these notions satisfy hereditary properties. We observe that all the concepts of intuitionistic fuzzy Hausdorff bitopological spaces are preserved under one-one, onto, fuzzy mappings.

F5] Various notions of Topological Transitivity in non-autonomous and generic dynamical systems

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We consider two types of dynamical systems namely non-autonomous discrete dynamical systems(NDDS) and generic dynamical systems(GDS). In both of them, we study various notions of transitivity. We give many equivalent conditions for each of these notions and present the implications among these in NDDS and GDS. For a given NDDS, we associate a GDS and discuss whether if the given NDDS has a particular variation of transitivity then the associated GDS also has such a variation and vice versa.

F7] Notes on Super Projective Modules

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Projective modules are a link between geometry and algebra as established by the theorem of Serre-Swan. We define the super analog of projective modules and explore this link in the case of some particular super geometric objects. We consider the tangent bundle over the supersphere and show that the module of vector field over a supersphere is a super projective module over the ring of supersmooth functions. Also, we discuss a class of super projective modules that can be constructed from a projection map on modules defined over the ring of supersmooth functions over superspheres.

F8] Generalization of Arc Shift for Twisted Knots

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Twisted knots are stable equivalence classes of oriented knots in orientable three-manifolds that are orientation I-bundles over closed but not necessarily orientable surfaces.

It is an extension of virtual knot theory and projective knot theory. In this field, the primary challenge is to categorize twisted knots based on their crossing numbers and differentiate them within stable equivalence classes. Twisted knot invariants play a crucial role in addressing this issue. This theory encompasses novel invariants for twisted knots, including the twisted Jones polynomial, the twisted link group, and Quandles for twisted links. Despite these strides, the range of known invariants for twisted knots remains limited compared to virtual knots, with not all virtual knot invariants extending to twisted knots. Notably, $n-$writhe, an invariant for virtual knots, is inapplicable to twisted knots. Unlike crossing change, virtualization serves as an unknotting operation for both virtual and twisted knots.

This paper addresses the challenge of identifying invariants for twisted knots. The study introduces the concept of arc shift moves as an unknotting operation for virtual knots and we establishes its effectiveness as an invariant for twisted knots. We also define the arc shift number and extend other virtual knot invariants, such as odd writhe, to the realm of twisted knots. The article concludes by presenting a class of twisted knots whose arc shift number is 1 and highlights open problems in this field.

F9] On Stronger Forms of Expansivity

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We define the concept of stronger forms of expansive map and call it as $\mathcal{F}$-expansive map. Further, we study examples, properties and extension of such maps. We also characterize $\mathcal{F}$-expansive map through $\mathcal{F}^*$ generator, where $\mathcal{F}$ and $\mathcal{F}^*$ are dual families of subsets of $\mathbb{N}$.

F10] Sensitivity and Equicontinuity in Non-Autonomous Discrete Dynamical Systems

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We consider non-autonomous discrete dynamical systems $(X, f_{1,\infty})$ where X is a metric space. We prove that if the system is transitive having a dense set of recurrent points with finite extended orbit and if the sequence (f_n) converges uniformly to a uniformly continuous one-one function, then the system is sensitive. We also prove that every point of equicontinuity for the collection of all finite itineraries is an extended transitive point for the given system. Similar result holds for generic dynamical systems also.

F11] Diagonal Property and Weak Point Property of Higher Rank Divisors and Certain Hilbert Schemes

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In this paper, we introduce the notion of the diagonal property and the weak point property for an ind-variety. We prove that the ind-varieties of higher rank divisors of integral slopes on a smooth projective curve have the weak point property. Moreover, we show that the ind-variety of $(1, n)$-divisors has the diagonal property. Furthermore, we obtain that the Hilbert schemes associated to the good partitions of a constant polynomial satisfy the diagonal property. In the process of obtaining this, we provide the exact number of such Hilbert schemes up to isomorphism by proving that the multi symmetric products associated to two distinct partitions of a positive integer n are not isomorphic.

F12] Behavior of the Universe with Varying Deceleration Parameter in Modified Theory of Gravity

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In the present research investigation, our focus is directed towards the examination of the anisotropic characteristics exhibited by the Universe within the theoretical framework of $f(R, L_m)$ gravity. This gravitational model, expressed as $f(R, L_m) = \frac{R}{2} + L_m^{\alpha} + \beta$, is a modification that integrates both the Ricci scalar (R) and the Lagrangian density associated with matter (L_m). The overarching objective of this study is to comprehend the dynamics of the Universe by scrutinizing the variable deceleration parameter within the specified modified gravity context.

To augment our analysis, we employ several analytical tools such as energy conditions, the jerk parameter, and statefinder parameters. These tools are instrumental in providing nuanced insights into the evolutionary trajectory of the Universe within the framework of $f(R, L_m)$ gravity. Our particular interest lies in elucidating the anisotropic features inherent in the cosmic evolution under consideration.

Furthermore, our investigation extends to a comparative analysis with recent observational data. The outcomes of this comparative analysis reveal a consonance between our findings and the predictions of the ΛCDM (Lambda Cold Dark Matter) model, a standard cosmological model. The agreement with the established ΛCDM model lends credence to the robustness and viability of our proposed $f(R, L_m)$ gravity framework in describing the observed cosmic dynamics.

In essence, this research endeavor yields valuable contributions to the understanding of the anisotropic nature of the Universe within the realm of $f(R, L_m)$ gravity. Additionally, the identified concordance with the ΛCDM model not only validates the theoretical framework but also accentuates the subtle deviations from the standard model, thereby affording a more profound comprehension of the fundamental dynamics governing our cosmic evolution.

F13] η-Ricci Yamabe Solitons on Lorentzian Para-Kenmotsu Manifolds

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In this paper we establish the geometric properties of η-Ricci Yamabe solitons on Lorentzian para-Kenmotsu manifolds. Here we discuss η-Ricci Yamabe solitons on Lorentzian para-Kenmotsu manifolds satisfying $R \cdot S = 0$. The results for η-Ricci Yamabe solitons on Lorentzian para-Kenmotsu manifolds with quasi-conformally flat are derived. In addition, we obtain results for η-Ricci Yamabe solitons on Lorentzian para-Kenmotsu manifolds admitting Codazzi type of Ricci tensor and cyclic parallel Ricci tensor, φ-quasi-conformally semi-symmetric, φ-Ricci symmetric and quasi-conformally Ricci semi-symmetric. At last, we construct an example of a such manifold which justify the existence of proper η-Ricci Yamabe solitons.

F14] Results on Ricci Solitons and Lorentzian α- Sasakian Manifolds of Invariant Submanifolds

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In this paper we focused on the study of geodesic property of invariant submanifold of Lorentzian α-Sasakian manifold. Additionally, we investigate various conditions for the second fundamental form π, namely 2-semiparallel, pseudoparallel, 2-pseudoparallel, Ricci-generalized pseudoparallel and 2-Ricci-generalized pseudoparallel and establish their equivalence. Finally we proved results related to Ricci solitons on invariant submanifolds of Lorentzian α-Sasakian manifolds.

Section G : Numerical Analysis, Approximation Theory and Computer Science

G3] Numerical Methods for Nonlocal Conservation Laws

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Conservation laws with non-local terms arise in a variety of physical applications. Space-integral terms are considered, for example, in models for granular flows, sedimentation, crowd motion, and traffic flow models. Macroscopic traffic flow models usually consist of one or two first-order hyperbolic partial differential equations accounting for the conservation of the number of cars, as defined in the LWR model. Equations with non-local flux have been recently introduced in traffic flow modeling to account for the reaction of drivers or pedestrians to the surrounding density of other individuals by approximating the problem by using the Lax-Friedrich scheme or the Godunov scheme, the well-posedness of entropy weak solutions for a class of scalar conservation laws with non-local flux in traffic modeling already in the literature. In the present study, we prefer a general approach to approximate the solutions of Non-local Conservation Laws. First we define our problem i.e, $\partial_t \rho + \partial_x F(t, x, \rho, R) = 0 \quad (t, x) \in \mathbb{R}^+ \times \mathbb{R}$, where ρ is the state variable, t the time, x the space variable, F a flux function and R an integral evaluation over the space. Typically, R is a convolution involving the state variable ρ over a possible compact space. Our approach will involve using precise quadrature rule to approximate the non-local term, and also using the Engquist-Osher scheme to estimate the problem's flux. We present specific conditions that a numerical flux function needs to fulfill. These conditions guarantee the convergence of the weak entropy solution of the considered model problem. We prove that numerical results validate the theoretical results, which can apply to non-local problems.

G4] Numerical Solution of Poisson Equation on Rctangular Domain by C^2-Powell-Sabin Element

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Poisson equation arises in many application, such as heat conduction, convection for the designation of rigid body dynamics, etc. Sometimes analytical solution of Poisson equation is very difficult to find. Due to this we rely on alternative methods. Some important numerical methods are finite difference method, finite element method, etc. In this work we consider the rectangular domain to solve Poisson's equation. We use popular C^2-Powell-Sabin (PS_{12}) element for this. First, we discretize the domain using uniform partition. On this partition, we find a collection of Powell-Sabin-Hermite basis functions. The coefficients of this linear combination are obtained using variational principles like Galerkin method. Since this is an approximation procedure, errors occur. Refinement of basis elements are used to find the coefficients. It is observed that as the refinement steps goes on increasing the approximation error decreases. Some numerical examples have been taken to justify the theory and procedure.

G5] A Generalized Quadrature Rule using Kronrod Extension

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This study introduces a novel Generalized quadrature rule, achieving a precision of eleven for the approximation line integrals of analytic functions. Developed through a Generalized technique (for n=2), the rule combines the Gauss-Legendre five-point rule and the Kronrod extension of the Lobatto four-point rule, both are of precision nine. An asymptotic error estimate for this rule is determined. Comparative analyses of errors are conducted through textual descriptions, tables, and figures, utilizing diverse text examples to assess the newly formulated rule and its constituent components. The integration of these rules into adaptive routines is explored, evaluating their operational effectiveness within these frameworks. Emphasis on the precision level highlights the Generalized quadrature rule's superiority over its constituent rules, demonstrating enhanced accuracy and efficiency. This study contributes a significant advancement in high-precision line integral approximation techniques with broad applicability.

G6] Geometric Integration of Langevin Dynamics for DNA Molecule

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The molecule of life performs various cellular tasks, such as replication, transcription, and packaging, using cellular machinery. Modeling and simulation of the DNA help us understand these essential cellular processes better. oxDNA is a coarse-grained model of the polymer that utilizes nucleotides as basic building blocks of the double-stranded helical molecule. In molecular dynamics, we model the nucleotides as rigid bodies that evolve in accordance with Newton's laws driven by conservative forces, thermal noise, drag, and hydrodynamic interactions. Langevin dynamics models solute-solvent interactions implicitly by coupling the system with a stochastic thermostat representing non-conservative forces. Although this coupling renders the system non-conservative, it results in a desirable diffusive behavior rather than a ballistic one. Moreover, the Langevin thermostats conserve the quaternion lengths as well as the orthogonality of quaternions and their conjugate angular momenta. We introduce and compare various splitting methods that preserve such qualitative properties of the Langevin dynamics.

G7] RBF-HFD and other Numerical Schemes for Time-Fractional Convection-Diffusion Equation

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We present Radial Basis Function based Hermite Finite Difference (RBF-HFD) scheme for solving time fractional convection diffusion equation (TFCDE). First we semi-discretize the TFCDE using fourth order RBF-HFD formulas in space variable. We make use of analytical expressions for weights with respect to Gaussian (GA) radial basis function in the RBF-HFD formulas. These analytical expressions are obtained by symbolic computation in Mathematica. Then we employ a $(4-\alpha)$ order scheme to approximate the Caputo time fractional derivative of order α $(0 < \alpha < 1)$ in the framework of an implicit scheme. Finally, the numerical scheme is validated by solving an initial-boundary value problem for TFCDE and the numerical results are compared with RBF-FD and fourth order compact finite difference scheme results. In comparison to the RBF-FD and Compact-FD methods, RBF-HFD method yield higher accuracy.

G8] On some Fourth Order Compact Numerical Schemes for Burgers' Equation

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We develop Radial Basis Function based Hermite Finite Difference (RBF-HFD) scheme for solving time-dependent PDE problems. We make use of fourth order RBF-HFD formulas to semi-discretize the PDE in space variable. Then we implement fourth order Runge-Kutta (RK-4) method to solve the semi-discretized system. Direct numerical computation of RBF-HFD formula weights suffers from ill conditioning and significant loss of accuracy. Therefore, we make use of analytical expressions for weights with respect to Multiquadric (MQ) radial basis function. These analytical expressions are obtained by symbolic computation in it Mathematica. An optimization algorithm is proposed for finding an optimal value of shape parameter based on minimizing the local truncation error of the differential operator. Then the numerical scheme is validated by solving an initial-boundary value problem for Burger's equation and the numerical results are compared with fourth order compact finite difference scheme results. We also locate the optimal values of the shape parameter.

G12] Structure-Preserving Numerical Integration of Constrained Hamiltonian Systems

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This talk presents a review of structure-preserving numerical methods of constrained Hamiltonian system. The aim of structure-preserving numerical methods is to preserve qualitative properties of a dynamical system. Conformal implicit midpoint rule (CIMP) and conformal Störmer–Verlet (CSV) method are proposed for such systems, which are conformal symplectic, symmetric, and second-order accurate. These methods are phase-space preserving methods. To obtain higher-order structure-preserving methods, we use these proposed integrators as the basis of a composition method.

G14] On a Posteriori Error Analysis for Weak Galerkin Finite Element Method for Parabolic Interface Problems

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In this talk, we present a posteriori error analysis of weak Galerkin finite element method for linear parabolic interface problems with non homogeneous jump conditions in a bounded convex domain in R^2. More precisely, we have considered the time stepping backward Euler approximation in time and the weak Galerkin finite element approximation for the space. An optimal order a posteriori error estimate is obtained with respect to the L^2- norm in time and the energy norm in space for the time stepping weak Galerkin approximation based on the backward Euler scheme for parabolic interface problems. The key ingredients used in the error analysis is the Helmholtz error decomposition method combined with the elliptic reconstruction technique and some partial orthogonality type relation in a proper framework.

G15] Comparative Study of Numerical Methods to Solve Second Order Non-Linear Differential Equation

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Differential equations play a crucial role in various fields of science and engineering. However, not all differential equations can be solved analytically. Numerical methods are used to obtain approximate solutions for such equations. In this paper, we focus on the numerical methods to solve a second order non-linear differential equation. We will compare the accuracy and efficiency of three numerical methods, namely, Euler's method, Runge-Kutta method, and Adams-Bashforth-Moulton method.

G16] A Nonconforming Least-Squares Spectral Element Method for Stokes Interface Problems

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In this paper, we discuss a least-squares spectral element approach for Stokes interface problems with smooth interfaces. The given domain is discretized into a finite number of subdomains so that the division matches along the interface. The interface is resolved exactly using blending elements. The higher order spectral element functions are used and they are nonconforming. A suitable least-squares functional is proposed. The interface conditions across the interface are enforced in appropriate Sobolev norms in the minimizing functional. The method is shown to be exponentially accurate and various numerical examples are presented to validate the theoretical estimates.

G17] A Priori Error Analysis of Weak Galerkin Mixed Finite Element Method for Parabolic Interface Problems

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The main aim of this talk is to study the time-stepping weak Galerkin mixed finite element method for linear parabolic interface problems in a bounded convex polygonal domain in $\mathbb{R}^2$. More precisely, we have considered both the spatially discrete and the fully discrete backward Euler weak Galerkin approximations for parabolic interface problems. Because of the discontinuity of the coefficients along the interface, the solution of parabolic interface problems have very low regularity in the entire domain. Therefore, the standard approximation results available in the literature can not be applied directly. Invoking the Stein extension operator along with the $H^1(\text{div})$ extension operator and some Sobolev embedding results, we have derived new approximation results for both the solution and the flux variables. Using a proper elliptic projection operator combined with some new approximation results, we have derived almost optimal order a priori error bounds for both the solution and the flux variables, respectively, in the $L^\infty(L^2)$ norm. Numerical results are reported to validate the theoretical results.

G18] *A Posteriori* Error Estimates for the Parabolic Partial Differential Equations with Small Random Input Data - Elliptic Reconstruction Approach

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Parabolic partial differential equations (PDEs) with small random input data appear in a wide range of physical and real-world applications, for instance, in the field of glaciology. In this work, we propose and investigate residual-based *a posteriori* error estimates for such equation in the $L^2_P(\Omega; L^\infty(0,T; L^2(D)))$-norm, where $(\Omega, \mathcal{F}, P)$ is a complete probability space, D is the physical domain, $T > 0$ is the final time. To this end, we employ perturbation technique to treat the uncertainty. With the use of this technique, solving a PDE with small random input data is equivalent to solving decoupled deterministic problems. Further, to obtain the approximate solution, we incorporate the finite element method and backward Euler time-stepping scheme for the approximation in space and time directions, respectively. Here, we employ the elliptic reconstruction approach to gain optimality in space. The current work could be seen as a generalization of the work presented in [2006, Math. Comput., 75, pp. 1627-1658] for the deterministic parabolic PDEs to the parabolic PDE with small uncertainties.

Section H : Solid Mechanics, Fluid Mechanics, Astrophysics and Relativity

H1] Compact Stars Under the purview of a modified theory of gravity with MIT Bag model

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This work reports the consequences of $f(T)$ gravity for compact star, Neutron star, Strange star. Firstly we have reported a reconstruction scheme for $f(T)$ gravity in presence of quintessence eld and numerically derived the radial evolution of the Modied Chaplygin Gas density for compact star and a decaying density has been observed along r. In the next phase the radial density has been chosen to be in the form of Modied Chaplygin Gas and same has been reconstructed under $f(T)$ gravity framework for neutron star. Evolution of radial density has been studied. Finally we have demonstrated Modied Chaplygin Gas under the purview of MIT bag model and considering the EOS of strange matter accordingly to MIT bag we have derived the expression for the density within a strange star as a function of radius r. It has been concluded that although the strange quark matter density is decaying, it increases after a certain stage.

H2] Study of bouncing scenario with multiplicative scale factor and some consequences are explored in modified gravity framework

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The study that is described in this paper investigates holographic bounce. In the initial phase of the study, we selected a non-singular bouncing scale factor. Then we have reconstructed $f(T)$ gravity and analytically derived constraints on the bouncing parameter σ. These constraints allowed us to understand the quintessence or phantom behaviour of the scale factor. Next, we considered the multiplicative bouncing scale factor and we discussed about a variety of singularities that could be realized for this scale factor for dierent values of α. Next, we analytically presented cases and sub-cases for dierent ranges of α of the scale factor through Taylor series expansion. In the study's nal phase, we demonstrated holographic bounce with the choice of the multiplicative scale factor. In this consequence, holographic Ricci dark energy and Barrow holographic dark energy were taken into account. We came into conclusion that it is possible to generate constraints on the bouncing parameter for its feasibility for the EoS parameter. We concluded that the realization of holographic bounce is possible and dierent suitable constraints can be derived for this multiplicative bouncing scale factor focusing on the realization of cosmic bounce.

H3] Cosmology with a Cosmological Basis

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The accelerating expansion of the universe attributed to dark energy requires further examination, as alternative frameworks (without Λ term) featuring negative q are gaining attention amid discrepancies in the standard model. From generalized Chaplygin gas (GCG) to Phantom energy models, these alternative models vary with an interaction term. In this context, we introduce category theory into cosmology. This is done by considering two distinct categories, with their morphisms establishing a correspondence between their interactions to understand the properties and effects of dark energy and dark matter through their interactions with visible matter. We categorize visible cosmic objects (e.g., stars, galaxies, clusters) and non-visible cosmic objects (dark energy and dark matter) within two categories under a framework called "Cosmological Basis." By doing so, the cosmological basis allows the study of structure-preserving maps between these entities, yielding unique morphisms or gravitational connections. We facilitate the introduction of cosmological basis by applying it to alternative dark energy models, drawing parallels with categorical quantum mechanics (CQM) and *nCob* in general relativity. Focusing on the GCG, we demonstrate the unification of a self-interacting quintessence and homogeneous phantom energy with GCG. We find that the interaction of homogeneous phantom energy and GCG within a strictly monoidal category is trivial to provide a unique representation of energy density and interaction terms to form a unified phantom Chaplygin gas. To this end, the cosmological basis offers the potential to explore beyond the boundaries of the standard model without the necessity of introducing new physics.

H4] Solution of Weyl-Lanczos Relations for Morris-Thorne Wormhole

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Wormholes, theoretical structures that connect disparate regions of spacetime, present intriguing possibilities for interstellar travel and exploitation. By the technique of differential forms, we have obtained Ricci rotation coefficients. The Lanczos potential is derived from the Weyl-Lanczos equations and general observer quantities. Also, through analytical calculations, we quantify the influence of the Lanczos potential on various physical quantities, such as tidal forces and shape function at the throat of the wormhole.

H5] Thermal management and irreversibility analysis of ternary hybrid nanofluids flow in a corrugated channel using finite element method

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A computational study is performed to examine the thermal performance and irreversibility of convective flow of ternary hybrid nanofluids in corrugated channel. Energy saving is an imperative issue in industrialization especially in thermal engineering, using of ternary hybrid nanofluid can play influential role in heat transferring mechanisms of thermal equipment. Different nanoparticles at different ratios are utilized as ternary-hybrid nanoparticles in this study. The channel is corrugated with trapezoid shaped includes heat source at its bottom wall while top surface is partially cooled. Maxwell thermal conductivity model with Brownian motions is implemented to estimate thermal conductively of the mixture fluids. The mathematical model is simulated using finite element method. Numerical code is validated performing comparisons based on existing results available in literature. The simulated results are presented via streamlines, isotherms, Nusselt number profiles and irreversibility components. The results highlighted that heat transfer rate increases significantly with increase in ternary-hybrid nanoparticles volume fraction which is correlated to the appropriate combination of nanoparticles and also optimization of irreversibility components. It is also recorded higher thermal performance in ternary hybrid nanofluid compared to nanofluid and hybrid nanofluids. The promising results of this investigation can expedite the thermal performances as potential cooling agents in improved designing to meet the demand of industrializations.

H6] Gravitational Deflection of Massive Body around Horava-Lifshitz Black holes

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The distortion of light-beam by massive particle around a gravitational field (suppose, black hole or wormhole) can be a support towards the magnitude used as a tune of gravity. As a consequence, bending of light-beam and fabricating multiple images against a luminous object is one of the interesting phenomena called gravitational lensing (Strong or weak). In this study, we have used the Jacobi metric, which we derived from the usual four dimensional spacetime metric, in order to study the angle of deflection of a mass less photon rays by massive particle around blackhole in Horava-Lifshitz spacetime, corresponding to two different component of this metric named as LMP and KS solution. We have used these two approaches to our comparative study for the angle of deflection, as stated by the method proposed by Gibbons and Werner employing the Gauss-Bonnet theorem. We graphically expressed the shape and redshift functions. We enumerate the bending of light as an angle of deflection which results for greater values of the impact parameter along with larger values of velocity of the massive body. In this article, we will explore the e?ect of the Horava-Lifshitz parameters on the black hole deflection angle and emphasize those features that permit a comparison between varieties of results within Horava-Lifshitz Einstein gravity.

H7] Influence of gravity on the quantum speed limit in neutrino oscillations

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The quantum speed limit (QSL) specifies the shortest amount of time required for a quantum system to evolve from an initial to a final state. In this work, we look into QSL for the unitary evolution of neutrinos and antineutrinos in the presence of a gravitational field. Since the transition probabilities between neutrino and antineutrino in the framework of one and two flavors depend on the strength of the gravitational field, the QSL time behaviour indicates fast flavor neutrino-antineutrino transitions as the gravitational field strength increases. Subsequently, we observe quick suppression of entanglement by exploring the speed limit for entanglement entropy of neutrino-antineutrino oscillations in the early universe and surrounding black holes.

H9] Evolving wormhole geometry from dark matter energy density

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We analyse traversable wormholes defined by the dynamic line elements that asymptotically approaches Friedmann-Robertson-Walker (FRW) universe. This dynamical wormholes is supported by the galactic dark matter as well as perfect isotropic fluid. We will discuss several evolving Lorentzian wormholes comprising with different perfect isotropic fluids in addition to various scale factors. We will speculate the various significance, features and throat energy conditions for these evolving Lorentzian wormholes.

H10] Deflection of massive body around wormholes in Einstein - Kalb - Ramond spacetime

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It is known that the deflection of massive body around a gravitating body (say, black hole or wormhole) can be used as a test of gravity, like deflection of light (bending of light i.e. gravitational lensing). In this study, we have used the Jacobi metric, which can be obtained from the usual spacetime metric, in order to study the angle of deflection of a massive body around wormholes in Einstein - Kalb - Ramond spacetime, considering two different models of wormholes corresponding to two different expressions of shape and redshift functions. We have used two approaches to our calculation of the angle of deflection, first according to the method proposed by Rindler and Ishak (2007); and second by employing the Gauss-Bonnet theorem. We have also compared the deflection angle obtained using the two approaches for the two wormhole models graphically. For the first model of the wormhole, we observed similar results for greater values of the impact parameter, whereas for the second model of the wormhole, the two approaches produced nearly identical results for smaller values of the impact parameter and larger values of velocity of the massive body.

H13] Wormhole geometries in $f(R,T)$ gravity theory

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This paper deals with the traversable wormhole geometries in $f(R,T)$ gravity theory, where R denotes the Ricci scalar and T is the trace of the energy-momentum tensor. Firstly, two new shape functions are obtained for some assumed generating function. Also, some new generating functions are obtained in wormhole geometry for some well known shape functions and redshift functions. Energy conditions are examined in each wormhole solution and it is found that a particular type of wormhole satisfies all the energy conditions in a region.

H14] Dispersion at the surface of a flexible seabed covered by a semi-infinite elastic floating plate

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This paper investigates the phenomenon of surface water waves being reflected and transmitted by the edge of a thin, semi-infinite elastic plate within a finite-depth ocean with a flexible bottom free of undulations. An investigation is conducted into the approximate analytical solution of the resulting boundary value issue by combining the Wiener-Hopf technique with the Fourier transform. Our objective when applying the Wiener-Hopf technique is to identify the two-part Wiener-Hopf functional relation that needs to be solved. In this functional connection, two unknowns that are analytic in a particular region are taken into account. Using analytical formulae, the reflection and transmission coefficients are eventually determined.

H15] The problem of surface wave scattering on an asymmetric rectangular trench revisited

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The problem of surface wave transformation over an asymmetrical trench is investigated in a finite depth of water within the framework of linear water wave theory. An infinite system of algebraic equations for amplitudes of traveling and evanescent modes is derived and solved numerically using Takano's approach for finding the transformation coefficients. This work aims to fill the gap in the literature by examining the behavior of transformation coefficients with respect to depth variation, an area that has not been extensively studied before. The characteristics of transformation coefficients are discussed in a comprehensive manner, which includes their non-monotonic dependence on the depth and trench width. In addition, the standing wave patterns for the region within the trench are also investigated. The results obtained are consistent with the law of energy flux conservation and give an accuracy of up to two digits. We believe that our findings will be helpful to coastal engineers in dispersing waves and reducing the incident wave energy before they reach the shoreline.

H16] Convective Viscous Fluid Flow Analysis over Porous Media with External Heat Source

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The present paper investigates the flow dynamics of a free convective fluid over a vertical porous medium. The study includes the occurrence of spontaneous heat and concentration diffusion along with the presence of an external heat source. The fluid is assumed to possess characteristics of viscosity, incomprehensibility, and certain mass in-fusibility. The current coupled model is being addressed through the utilization of a finite difference scheme(FDS), which possesses an implicit nature and is highly stable. Numerical configurations are employed to illustrate the results graphically, allowing for the study of flow behavior. Momentum, energy, concentration diffusion, and skin friction are analyzed across various parameters such as Schmidt number, Prandtl number, external heat source parameter, permeability parameter, and both mass and thermal Grashof numbers. The present study has yielded noteworthy findings, particularly the external heat source intensifies fluid flow while maintaining a relatively temperature distribution throughout the system. A brief comparison between the Schmidt number and the porosity parameter was explored and it was observed that the flow speed decreases with an increase in Schmidt parameter, however, when higher porosity is present, the deceleration occurs at a slower rate. As the external heat source parameter increases, the temperature profile also rises.

H17] Dynamical system analysis of scalar field cosmology in coincident $f(Q)$ gravity

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In this article, we investigate scalar field cosmology in the coincident $f(Q)$ gravity formalism. We calculate the motion equations of $f(Q)$ gravity under the flat Friedmann-Lemaître-Robertson-Walker background in the presence of a scalar field. We consider a non-linear $f(Q)$ model, particularly $f(Q) = -Q + \alpha Q^n$, which is nothing but a polynomial correction to the STEGR case. Further, we assumed two well-known specific forms of the potential function, specifically the exponential from $V(\phi) = V_0 e^{-\beta\phi}$ and the power-law form $V(\phi) = V_0\phi^{-k}$. We employ some phase-space variables and transform the cosmological field equations into an autonomous system. We calculate the critical points of the corresponding autonomous systems and examine their stability behaviors. We discuss the physical significance corresponding to the exponential case for parameter values $n = 2$ and $n = -1$ with $\beta = 1$, and $n = -1$ with $\beta = \sqrt{3}$. Moreover, we discuss the same corresponding to the power-law case for the parameter value $n = -2$ and $k = 0.16$. We also analyze the behavior of corresponding cosmological parameters such as scalar field and dark energy density, deceleration, and the effective equation of state parameter. Corresponding to the exponential case, we find that the results obtained for the parameter constraints in Case III is better among all three cases, and that represents the evolution of the universe from a decelerated stiff era to an accelerated de-Sitter era via matter-dominated epoch. Further, in the power-law case, we find that all trajectories exhibit identical behavior, representing the evolution of the universe from a decelerated stiff era to an accelerated de-Sitter era. Lastly, we conclude that the exponential case shows better evolution as compared to the power-law case.

H18] Scattering of oblique water waves by two vertical barriers over a trench type bottom

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The problem involving the interaction of obliquely incident surface water waves with two rigid surface-piercing thin vertical plates having unequal lengths over trench-type bottom topography is investigated in a channel of finite depth using linear water wave theory. Using the eigenfunction expansion method, the series solution involving eigenfunctions through the matching conditions leads us to a system of over-determined algebraic equations. These equations are solved using the algebraic least-square method. The present results for the physical quantities such as reflection coefficient and transmission coefficient are in good agreement with various previous results. These hydrodynamic quantities' behavior is examined for a range of various physical parameters. Also, some important results such as wave elevation and dimensionless horizontal force are investigated and analyzed through graphs. Two unequal surfaces piercing thin vertical rigid barriers over a trench-type bottom topography may be an effective way of decreasing the impact of ocean waves on the seashore.

H19] Unsteady MHD Flow of Visco-Elastic Maxwell Fluid through rectangular Porous tube

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The flow of an electrically conducting visco-elastic Maxwell fluid through porous straight tube of rectangular cross section has been studied. The flow has been considered in presence of uniform transverse magnetic field B_0. The motion is under the influence of a time varying pressure gradient. The analytical solution of the velocity has been obtained by using integral transform technique. We have investigated a few particular cases of pressure gradient. The corresponding viscous flow problem has been studied. The effect of pertinent parameters such as Maxwell parameter (λ), magnetic parameter (M) and porosity parameter (K_p) over the flow field which characterize the flow phenomena has been studied with help of graphs.

H20] Dynamical System Analysis in Teleparallel Gravity with Boundary Term

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In this paper, we perform the dynamical system analysis of the cosmological models framed in the extended teleparallel gravity, the $f(T, B)$ gravity. The critical points are obtained in two well-motivated forms of $f(T, B)$, one that involves the logarithmic form of the boundary term B, and the other one is the non-linear form of the boundary term. The position of critical points is shown in the different evolutionary phases of the Universe such as radiation, matter, and de-Sitter phase. The stability condition of each of the critical points of both the models is derived and the behavior of each point has been obtained mathematically and through the phase portrait. The evolution of standard density parameters such as radiation (Ω_r), matter (Ω_m), and dark energy (Ω_{DE}) are also analyzed. Further to connect with the present cosmological scenario, the behavior of deceleration and equation of state parameter both in the dark energy phase (ω_{DE}) and total (ω_{tot}) are shown from the initial condition of the dynamical variables. The accelerating behaviour has been obtained for both models.

H22] Unsteady MHD Bio-convective Transport of Oxytactic Microorganisms with Thermal Radiation and Chemical Reaction over a stretching Cone

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The multi-effect bio convective heat transfer in porous media is essential for many technological applications. However, the literature governing for practical applications are very scarce. The bio convective transport of magnetohydrodynamic(MHD, Casson nanofluid carrying oxytactic microorganisms across a stretching cone with velocity slip, thermal radiation, and chemical reaction in Darcy Brinkman Forchheimer (DBF) porous medium is predicted in this piece of work. The random movement and thermophoresis processes are revealed by the Buongiorno model. By using a suitable similarity transformation and boundary layer approximation, the siplified model equations are converted into coupled highly nonlinear Ordinary differential equations(ODEs). The resulting ODEs are dealt with numerically utilizing the BVP4C and the shooting method with predetermined thermal radiation, chemical reaction etc. Overall, this study will help researchers in science and engineering to understand the intricate and multieffective dynamics of the proposed model.

H24] Wormhole solutions supported by non-commutative geometric background in $f(Q,T)$ gravity

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The aim of this manuscript is to investigate the existence of spherically symmetric wormhole solutions in the context of extended symmetric teleparallel gravity by involving some aspects of non-commutative geometry. To accomplish this, we study a linear model $f(\mathcal{Q},\mathcal{T}) = \alpha\mathcal{Q} + \beta\mathcal{T}$ with anisotropic matter distribution in two different scenarios. In the first scenario, the behavior of traceless matter is studied to describe the important properties of the shape function under Gaussian and Lorentzian distributions. Next, we examine a linear equation of state for radial pressure with both distributions. Further, several interesting points have evolved from the entire investigation along with features of the exotic matter within the wormhole geometry. Finally, we have concluding remarks.

H25] A computational investigation of microbial dynamics of MHD Casson nanoliquid flow past an inclined porous stretching plate

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Non-Newtonian biofluids have extensive applications in multidisciplinary fields which include biofuels, blood circulation, and other biological phenomena. In this direction, the present investigation provides a mathematical framework of a non-Newtonian nanofluid past an inclined porous stretching plate. The flow rheology is observed under the effect of external magnetic field, thermal radiation, chemical reaction, and heat source. The governing set of Partial Differential Equations (PDEs) is obtained using the Casson fluid model and the nanofluid characteristics are explored using the Bungirno model. The suitable similarity invariants are introduced to convert the set of PDEs into a set of nonlinear Ordinary Differential Equations (ODEs). The raised physical parameters are graphically interpreted through MATLAB and numerical outcomes are validated using a previously published work. It is observed that the density profile declines with increasing values of Schmidt number and bioconvection Schmidt number.

H26] Anisotropic quintessence compact star in $f(T)$ gravity with Tolman-Kuchowicz metric potentials.

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We present an analytically relativistic quintessence anisotropic compact object's solution with spherically symmetric matter distribution in f(T) gravity. We imposed pressure anisotropy condition along with a metric potential of the Tolman-Kuchowicz type.We also cogitate that our current model incorporates a quintessence field charecterized by a parameter ω_q . In presence of the parameter α the field equations are modified by the choice of the f(T) function.The stellar model is analyzed by the f(T) gravity parameter α. We consider the compact star Her X-1 and varying α from 0.5 to 2.5,we examined all the physical charecteristics of the model parameter and configuration. The graphical process demonstrates that a more compact item is produced with greater values of α . The hydrostatic equilibrium condition of the model is discussed as well as the mss-radius relationship for our current model is obtained.

H27] Fabricating the Joule heating and second order chemical reaction on nanofluid flow towards a Stagnation point: Lie group approach

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This research elucidates the detail analysis of an electromagnetic radiative flow of a nanofluid over an expanded sheet close to a stagnation point. The flow experiences the couple effect of externally applied electric and magnetic fields, which in turn creates the Joule heating within the energy equation. The impact of the linear thermal radiation and the second order chemical reaction is also recorded under the influence of multiple slips at the solid liquid interface, which makes this model more realistic and practically applicable. The Lie group transformation is employed to bring the similar solution of the governing non-linear partial differential equations. The numerical solution is achieved by employing the RKF 45 method coupled with shooting procedure. Tables of comparison have also generated, showcasing a remarkable concordance with the prevailing literature. Graphs and tables have been compiled to illustrate the effects of various pertinent parameters on the flow field, as well as on the skin friction coefficient, Nusselt number, and Sherwood number. One of the important findings reveals that the velocity slip parameter declines the flow rate while enhancing the temperature and the nanoparticle concentration near the wall. Another upshot interprets that the thermal and the nanoparticle concentration boundary layer width decay with the chemical reaction rate parameter. Alongside, the rate of heat transportation coefficient found to be increased by 3.66 % with the velocity slip parameter while ranging from $0.05 \leq \xi \leq 0.2$ but within the range of $0.1 \leq \xi \leq 0.9$ the reverse impact by 11.93% is notable for the Sherwood number.

H28] Aerodynamic Simulations for Realistic car moving in Dusty Fluid Medium

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The automotive industry requires accurate CFD simulation methods to handle the complex turbulent airflow around vehicles.In this study, a dusty fluid medium using the RANS Realizable k-ϵ turbulence scheme is introduced to investigate the impact of suspended dust particles in the air on the drag coefficient and the aerodynamic flow field past a realistic car. Simulation results of drag coefficients in the dusty fluid medium are compared with existing experimental results and single-phase turbulence simulation results pertaining to clear air. Further, the pressure, velocity, and turbulent kinetic energy contours at the symmetric plane of the realistic car depicted through figures for the volume fraction of dust particles ϕ =0.1, 0.3 in dusty fluid medium and compared them with that of clear fluid medium for ϕ= 0.0. Findings indicate that suspended dust particles in the air attenuate the total drag coefficient. It is concluded that aerodynamic flow simulation in dusty fluid medium could be a better simulation technique than single-phase simulations in clear fluid medium.

H29] Traversable wormhole solutions in Barber's second self-creation theory

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Wormholes are topological handles that connect two spacetimes of the same universe or of different universes by a minimal surface (the throat of the wormholes). Wormholes have been constructed not only in Einstein's general theory of relativity (GTR) but also in the other modified gravitational theories. In this paper, we propose a new traversable wormhole model in Barber's second self-creation theory. We derive an exact wormhole solution that satisfies the null and weak energy conditions. Further, we use causality and the Herrera cracking technique to study the stability of the wormhole. Therefore, a traversable wormhole solution exists in Barber's second self-creation theory.

H30] Heat and Mass Transfer of Water-based Nanofluid with Electrification of Nanoparticles

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Heat and mass transfer analysis in free convective alumina-water nanofluid flow with electrified alumina-nanoparticles over a vertical plane wall has been carried out. The nanoparticle electrification mechanism has been introduced in modelling free convective nanofluid flow to study the impact of electrified nanoparticles on the heat and mass transfer of water-based nanofluid. The governing equations of the flow field are reduced to locally similar equations employing similarity variables and are solved using the MATLAB bvp4c package. The variations of non-dimensional temperature, concentration and velocity, as well as the heat and mass transfer coefficients with nanoparticle electrification and free convection parameters, are analyzed through figures and tables. It is observed that nanoparticle electrification improves the heat and mass transfer capabilities of alumina-water nanofluid. Hence, it is revealed that nanoparticle electrification could be a new phenomenon to enhance the heat and mass transfer of the alumina-water nanofluid flow. Further, this phenomenon could be applied in industrial applications to enhance the heat transfer rate of nanofluids.

H31] Bianchi Type$-III$ Cosmological Models in $f(Q)$ Gravity

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In this study, we considered $f(\mathbb{Q})$ gravity, a version of symmetric teleparallel gravity in which the nonmetricity, $\mathbb{Q}$ serves as the key building block to describe spacetime. For this purpose, we have investigated four different cosmological models of Bianchi type$-III$ space-time by choosing some well-prompted forms of $f(Q)$, such as $(i) f(\mathbb{Q}) = \mathbb{Q}$, $(ii) f(\mathbb{Q}) = \mathbb{Q} + m(1 - e^{-\mathbb{Q}})$, here m is a positive arbitrary constant, $(iii) f(\mathbb{Q}) = C_1 + C_2 log\mathbb{Q}$ where C_1, C_2 are arbitrary constants, and $(iv) f(\mathbb{Q}) = \alpha_1\mathbb{Q} + \beta_1\mathbb{Q}^l$ here α_1, β_1 and $l \neq 1$ are free parameters. Furthermore, in all the models, the null, weak, and dominant energy conditions are obeyed while violating strong energy conditions as per the present scenario of the accelerating expansion.

H33] Accelerating cosmological models in $f(Q)$ gravity and the phase space analysis

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The dynamical aspect of accelerating cosmological model has been studied in this paper in the context of modified symmetric teleparallel gravity, the $f(Q)$ gravity. Initially, we have derived the dynamical parameters for two well known forms of $f(Q)$ such as: (i) log-square-root form and (ii) exponential form. The equation of state (EoS) parameter for the dark energy in the $f(Q)$ gravity in both the models emerges into a dynamical quantity. At present model-I shows the quintessence behavior and behave like the ΛCDM at the late time whereas model-II shows phantom behaviour. Further, the dynamical system analysis has been performed to determine the cosmological behaviour of the models along with its stability behaviour. For both the models the critical points are obtained and analysed the stability at each critical points with phase portraits. The evolutionary behaviour of density parameters for the matter-dominated, radiation-dominated, and dark energy phases are also shown for both the models.

H34] Constraining Anisotropic Cosmological Model in $f(R, L_m)$ Gravity

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The observational evidence regarding the present cosmological aspects tells us about very little anisotropy in the universe on a large scale. In this paper, we attempt to study locally rotationally symmetric (LRS) homogeneous Bianchi-I spacetime with the isotropic matter distribution. This is done within the framework of $f(R, L_m)$ gravity. Particularly, we consider a non-linear $f(R, L_m)$ model, $f(R, L_m) = \frac{1}{2}R + L_m^{\alpha}$. Furthermore, ω, the equation of state parameter, which is vital in determining the universe's present phase, is constrained. To constrain the model parameters and the equation of state parameter, we use 57 Hubble data points and 1048 Pantheon supernovae type Ia data samples. And, for our statistical analysis, we use Markov Chain Monte Carlo (MCMC) simulation. Moreover, with the help of obtained values of parameters, we measure the anisotropy parameter for our model.

H35] Global phase space analysis for a class of single scalar field bouncing solutions in general relativity

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We carry out a compact phase space analysis of a non-canonical scalar field theory whose Lagrangian is of the form $F(X) - V(\phi)$ within general relativity. In particular, we focus on a kinetic term of the form $F(X) = \beta X^m$ with power law potential $V_0\phi^n$ and exponential potential $V_0 e^{-\lambda\phi/M_{Pl}}$ of the scalar field. The main aim of this work is to investigate the genericity of nonsingular bounce in these models and to investigate the cosmic future of the bouncing cosmologies when they are generic. A global dynamical system formulation that is particularly suitable for investigating nonsingular bouncing cosmologies is used to carry out the analysis. We show that when $F(X) = \beta X^m$ ($\beta < 0$), nonsingular bounce is generic for a power law potential $V(\phi) = V_0\phi^n$ only within the parameter range $\left\{\frac{1}{2} < m < 1,\ n < \frac{2m}{m-1}\right\}$ and for an exponential potential $V(\phi) = V_0 e^{-\lambda\phi/M_{Pl}}$ only within the parameter range $\left\{\frac{1}{2} < m \leq 1\right\}$. Except in these cases, nonsingular bounce in these models is not generic due to the non-existence of global past or future attractors. Our analysis serves to show the importance of a global phase space analysis to address important questions about nonsingular bouncing solutions, an idea that may and must be adopted for such solutions even in other theories.

H36] Optimally Weighted Least Squares Kinetic Meshfree Method for Inviscid Compressible Flows

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The least squares kinetic upwind method (LSKUM) is a kinetic theory-based meshfree scheme for the numerical solution of compressible fluid flows. It operates on a distribution of points, known as a point cloud. The cloud of points can be obtained from structured, unstructured, or even chimera grids. LSKUM is based on the moment method strategy, where an upwind scheme for the governing equations is first developed using kinetic flux vector splitting. Later, the spatial derivatives of the split fluxes are approximated using the weighted least-squares principle applied to a point cloud. The robustness and accuracy of LSKUM depend on the condition number of the weighted least-squares matrix associated with the approximation of spatial derivatives. In computational domains with a highly stretched or anisotropic distribution of points, the least-squares matrix experiences high condition numbers, which results in either loss of accuracy, poor convergence, or even CFD code divergence. The weights proposed in earlier research are not aimed at obtaining minimal condition numbers or truncation errors in weighted least-squares formulae. Therefore, the computed numerical solution may not be accurate. In this research, an attempt has been made to find the optimal weights that enhance the robustness and accuracy of LSKUM for two-dimensional inviscid flows. The optimal weights that result in minimal condition numbers are found using discrete adjoints based on algorithmic differentiation. Numerical results have shown that the optimally weighted LSKUM yielded a more accurate solution with better convergence than the current strategies for weights.

H37] Dynamic analysis of holographic dark energy in f(R) gravity via observational constraints

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The work is devoted to study hypersurface-homogeneous cosmological model with holographic dark energy in the framework of $f(R)$ gravity. The exact solutions of the field equations are deduced by considering the hybrid, exponential and power-law volumetric expansion. Various physical and kinematical properties of the models are discussed. The observational constraints and energy conditions are investigated for the models. In addition to make our interpretation clearer, we have taken the state finder diagnostic pair $\{r, s\}$ and stability analysis of discussed models. In this work, the obtained results resemble with recent observational data and provide a simple description of the transition from deceleration to cosmic acceleration of the universe.

H39] Non-interacting String and Holographic Dark Energy Cosmological Models in f(R) Theory of Gravity

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In this paper, a new class of string and holographic dark energy (HDE) cosmological model in the context of $f(R)$ theory of gravity using the Kasner metric is considered. The exact solutions of the field equations are obtained by using the relation between the average scale factor and the scalar function $f(R)$. It has been observed that the universe is accelerating and expanding. The string phase of the universe is present at an early stage of the evolution of the universe. The universe is dominated by quintessence-type HDE at present. The effect of the curvature function $f(R)$ is also observed on dynamical parameters.

H40] EMHD Flow in a Porous Curved Microchannel with Peristaltic Wall Deformation

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This theoretical analysis explores into the intricate dynamics of peristaltic transport within a curved microchannel incorporating a porous medium, with a particular emphasis on its potential applications in blood flow management. The governing equation for momentum is systematically solved using numerical methods, allowing for a comprehensive exploration of the electromagnetohydrodynamic (EMHD) effect. This investigation scrutinizes the influence of key parameters, such as the Hartmann number, curvature parameter, and Darcy number, on flow behaviour characteristics. Notably, the analysis reveals a peak velocity in the upper half of the microchannel. The increment in the curvature parameter induces significant deformations in the microchannel structure, resulting in increased resistance to flow. Consequently, the overall flow rate experiences a reduction due to the deformation of the curved microchannel. This observation underscores the intricate interplay between curvature and porous effects in shaping the flow dynamics within microchannel. The implications of these findings extend notably to medical technology and microscale fluidic systems, offering valuable guidance for the design and fabrication of microfluidic devices aimed at enhancing heat dissipation and optimizing transport properties in curved geometries.

H41] Autonomous system for the late-time cosmological models and their stability in higher-curvature gravity with boundary terms

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Cosmological dynamics are investigated in detail through systematic procedures by using the autonomous system analyses of gravitational field equations in higher-curvature gravity with the boundary terms, corresponding to the non-metricity scalar. The explicit analyses of the late-time cosmic evolutions are demonstrated for two fundamental types of models from the literature: the power law, $f(Q) = Q + mQ^n$, and the logarithmic, $f(Q) = \alpha + \beta logQ$ models, under the presence of perturbation. The stability of cosmological solutions is also explored by examining non-hyperbolic critical points in the framework of the center manifold theory. For the power law model, we achieve a matter-dominated saddle point with the right matter perturbation growth rate. For the logarithmic model, we get a saddle point dominated by the geometric component of the $f(Q)$ model with perturbations in the decomposition of matter. For both models, we later achieved a stable and accelerating Universe with constant matter perturbations.

H42] Physical Characteristics and Maximum Allowable Mass of Hybrid Star in the Context of f(Q) Gravity.

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In this study, we explore several new characteristics of a static anisotropic hybrid star with strange quark matter (SQM) and ordinary baryonic matter (OBM) distribution. Here, we use the MIT bag model equation of state to connect the density and pressure of SQM inside stars, whereas the linear equation of state $p_r = \alpha\rho - \beta$ connects the radial pressure and matter density caused by baryonic matter. The stellar model was developed under a background of $f(Q)$ gravity using the quadratic form of $f(Q)$. We utilized the Tolman-Kuchowicz ansatz [R. C. Tolman, Phys. Rev. 55 (1939) 364–373; B. Kuchowicz, Acta Phys. Pol. 33 (1968) 541] to find the solutions to the field equations under modified gravity. We have matched the interior solution to the external Schwarzschild spacetime in order to acquire the numerical values of the model parameters. We have selected the star Her X-1 to develop various profiles of the model parameters. Several significant physical characteristics have been examined analytically and graphically, including matter densities, tangential and radial pressures, energy conditions, anisotropy factor, redshirt, compactness, etc. The main finding is that there is no core singularity present in the formations of the star under investigation. The nature of mass and the bag constant B_g have been studied in details through equi-mass and equi-B_g contour. The maximum allowable mass and the corresponding radius have been obtained via $M - R$ plots.

H44] Observational constraints on generalized dark matter properties in the presence of neutrinos with the final Planck release

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In this paper, we investigate an extension of the standard ΛCDM model by allowing: a temporal evolution in the equation of state (EoS) of DM via Chevallier-Polarski-Linder parametrization, and the constant non-null sound speed. We also consider the properties of neutrinos, such as the effective neutrino mass and the effective number of neutrino species as free parameters. We derive the constraints on this scenario by using the data from the Planck-2018 cosmic microwave background (CMB), baryonic acoustic oscillation (BAO) measurements, Pantheon+ compilation of Type Ia supernovae (SNe Ia), and some large scale structure (LSS) information from the cosmic shear surveys: Kilo Degree Survey (KiDS)-1000 and Dark Energy Survey (DES). We find constraints on the EoS and sound speed of DM very close to the null value in all the analyses, and thus no significant evidence is found beyond the standard CDM paradigm. In all the analyses, we find the significantly tight upper bounds on the sum of neutrino masses, and significantly lower mean values of S_8, which are in agreement with the LSS measurements. Thus, the well-known S_8 tension is reconciled in the considered model.

H45] Reconstruction of LCDM universe in f (Q) gravity

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In this manuscript, we present a number of fascinating explicit reconstructions for the $f(Q)$ gravity from the background of Friedmann-Laîmatre-Robertson-Walker (FLRW) evolution history. We find the more general functions of non-metricity scalar Q that admit exact ΛCDM expansion history. Adding extra degrees of freedom to the matter sector is the only method to get the scale factor to behave in this manner for more generic functions of Q. In addition, a cosmological reconstruction for modified $f(Q)$ gravity is constructed in terms of e-folding. It is shown how any FLRW cosmology can arise from a specific $f(Q)$ theory. We also reconstruct the well-known cosmological evolution for the specific examples of ΛCDM cosmology.

H46] Dispersive constraints of Anti-plane Shear waves in a strain-gradient LoH model under inflexible boundary plane and initial pressure

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This research work depicts the dispersive limitation of SH waves in an initially stressed strain gradient LoH model with an inflexible upper boundary plane. The gradient elasticity theory developed by Mindlin (Arch. Ration. Mech. Anal. 16:51–78, 1964) serves as the framework for this study. This theory is based on some cornerstones like the introduction of internal structures at different scales and the nonlinearity of the models which in other words means incorporating intrinsic microstructural and nonlinear effects. As a result, the dispersion relations have been deduced analytically by imposing the required interface and the intrinsic boundary conditions. The agreement to the classical case is presented as a particular case along with various other cases obtained by freeing some assumptions from the model. The distinguished region of existence of the dispersion curves has been plotted and discussed in detail by deriving the upper and lower bound for the phase velocity of the SH wave. Additionally, the influence of various strain-gradient elastic parameters has been examined using contour plots, and it has been found that the features of SH waves are a lot more diverse in the strain gradient case as compared to the classical situation.

H47] Thin-Shell Gravastar Model in f(Q,T) Gravity

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In the last few decades, gravastars have been proposed as an alternative to black holes. The stability of the gravastar has been studied in many modified theories of gravity along with Einstein's GR. The $f(Q,T)$ gravity, a successfully modified theory of gravity for describing the current accelerated expansion of the Universe, has been used in this article to study gravastar in different aspects. According to Mazur and Mottola, it has three regions with three different equations of state. Here in this work, we have studied the interior of the gravastar by considering the $p = -\rho$ EoS to describe the dark sector for the interior region. The next region is a thin shell of ultrarelativistic stiff fluid, in which we have investigated several physical properties, viz., the proper length, energy, entropy, surface energy density, etc. In addition, we have studied the surface redshift and speed of sound to check the potential stability of our proposed thin-shell gravastar model. Apart from that, we have used the entropy maximization technique to verify the stability of the gravastar model. The gravastar's outer region is a complete vacuum described by exterior Schwarzschild geometry. Finally, we have presented a stable gravastar model which is singularity-free and devoid of any incompleteness in classical black hole theory.

H48] Electrification effect of nanoparticles on the analysis of heat and mass transfer of nanofluids over a stretching cylinder

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The present investigation explores the flow and heat transfer of a viscous, incompressible and electrically non-conducting nanofluid over a stretching cylindrical surface with the electrification effect of nanoparticles, in the presence of viscous dissipation. The non-linear partial differential equations, governing to the problem, are transformed into non-linear ordinary differential equations by using adequate similarity transformations and then solved using bvp4c function of Matlab software. To validate the accuracy of obtained numerical results, a comparison has done with the previously published paper. Then the numerical results of velocity, temperature, and concentration are depicted graphically. It has observed that electrification effect of nanoparticles is a possible mechanism for heat transfer enhancement of working fluid.

H49] Effect of Transvers Force on Fluid Flow Over a Linear Stretching Sheet with Fluid Particle Suspension

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This research presents a numerical investigation of the flow and heat transfer of a steady dusty flow over a linear horizontal stretching sheet. Transverse force effects have been taken into account. The flow problem's formulation comprises of highly nonlinear PDEs that have been transformed into systems of ODEs by using similarity transformation. Then the ODEs has been solved numerically by using Shooting technique followed by Runge Kutta 4th order method that is incorporated in BVP4C tool of the MATLAB software. The effects various flow parameters, such as the Prandtl number, Eckert number and transverse force on the flow geometry has been investigated. The overall findings are displayed in graphs and tables, and it is discovered that the transverse force reduces the velocity of the particle phase in the flow. Our results has been validated with existing literatures and found agrees with very good way.

H50] Dynamical System analysis in f(T) gravity at both background and perturbation levels

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In this paper, we have performed the dynamical system analysis of $f(T)$ gravity cosmological models at both background and perturbation levels. We have presented three models pertaining to three distinct functional forms of $f(T)$. The first form is that of the logarithmic form of the torsion scalar T, the second one is in the power law form, and the third one is the combination of the first two forms. For all these three forms of $f(T)$, we have derived the corresponding cosmological parameters in terms of the dynamical variables. Subsequently, the critical points are obtained and the condition(s) of its existence has been derived. Critical points of each model have been analysed individually and the corresponding cosmology are derived. The stability behaviour of these critical points are discussed from the behaviour of the eigenvalues and the phase portraits. At least one stable node has been obtained in each of these models. Further from the evolution plots of the cosmological parameters, the accelerating behaviour of the cosmological models are also verified.

H54] A study of axisymmetric oscillatory Stokes flow past a sphere

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The general solution for the problem of Stokes flow past a sphere in an axisymmetric oscillatory flow of an incompressible, viscous fluid with slip-stick boundary conditions is obtained. The stream functions are obtained for the examples of axisymmetric flows considered, and some physical quantities are computed using them. The streamlines are plotted, and the flows are analyzed. Some existing results are obtained as special cases.

H56] Longitudinal plane wave scattering at the surface of pre-stressed piezoelectric semiconductor slab

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Present investigation centres on examining the behaviour of obliquely incident longitudinal quasi-plane (qP) on open surface of an initially stressed N-type piezoelectric semiconductor (PSC) slab. When a qP wave impinges upon the PSC slab's surface, it gives rise to four interlinked reflected waves: two elastic waves (reflected qP wave and qSV wave), an electro-acoustic (EA) wave, and a carrier plane (CP) wave. This article undertakes a theoretical analysis of the amplitudes associated with each reflected partial wave mode within the PSC slab under different types of initial stress applied on the body. The derivation of the secular equation of general plane waves, along with the analytical determination of reflection coefficients, has been successfully achieved by leveraging 3-D constitutive relations and equilibrium equations governing the PSC medium. Furthermore, the study delves into the computation and conservation of bulk energy flux. By utilizing Zinc-Oxide semiconductor as an illustrative example, the research explores how steady state electron density and initial stresses impact the amplitudes of reflected partial waves. The outcomes of this research carry potential implications for the practical applications of piezoelectric semiconductors. By shedding light on the intricate dynamics of wave interactions in PSC slabs, the finding contributes valuable insights that may inform advancements in relevant technological domains.

H58] Stability of Bianchi Type-II Cosmological Model in Saez-Ballester Theory of Gravitation

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In this paper, Bianchi type-II cosmological model is studied in presence of Saez-Ballester scalar tensor theory of gravitation and an energy momentum tensor of an anisotropic dark matter distribution. Exact solutions of eld equations are obtained by the law of Hubble parameter and relation between metric coecients. The model's stability is examined in terms of the speed of sound, Aberu's stability condition, and the causality condition. We also investigated the physical properties of the resulting cosmological model, including its radial and transverse pressure, energy density and an anisotropy factor.

H60] Bianchi Type-I Cosmological Models with General Relativistic Hydrodynamics in f(R) Theory of Gravitation

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In the present article, we investigate Bianchi type-I models in the context of the $f(R)$ theory of gravity using general relativistic hydrodynamics. The power law and exponential volumetric expansions are used to obtain the exact solutions to the field equations. Various physical and kinematic features of the investigated models are described. In addition, to further clarify our view, we used the statefinder diagnostic pair and cosmic jerk parameter to describe the different phases of the universe. In each case, the function of the Ricci scalar is also evaluated.

H62] Bianchi type-III cosmological model with Holographic dark energy matter in F(R) theory of gravitation

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We have investigated the Bianchi type-III Cosmological model with holographic dark energy matter in F(R) Theory of Gravitation, some geometrical and physical behavior of Bianchi type III cosmological model are discussed.

H63] Traversable wormhole filled with various matter fluids in the Rastall gravity

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In the present work, we have studied traversable wormhole in Rastall gravity formalism. Rastall's theory belongs to the class of non-conservative theories of gravity. In vacuum, the only non-trivial static, spherically symmetric solution is the Schwarzschild one, except for a very special case. We investigate the throat of wormhole filled with various matter fluids. Formulation of field equations in this modified gravity have also been presented. The behaviour of energy conditions are discussed to describe the traversable wormhole. This would be interesting to find out the matter fluids and their properties has any effect on the traversable wormholes and their corresponding energy conditions and existence of the exotic matters.

H64] Scattering across an elastic bottom along the edges of two pairs of semi-infinite elastic floating plates

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The present investigation examines the transmission and reflection of surface water wave scattering by the edges of two thin, semi-infinite elastic plates that are floating in an ocean, taking into account the seabed's flexibility and flatness. Using a Fourier transform and the Wiener-Hopf approach, the approximate analytical solution of the resultant boundary value problem is examined. This research considers the velocity potential to be the total of the diffraction and incident wave potentials. Our goal is to solve the diffraction potential using the previously mentioned approach. Finally, analytical formulas are obtained for the first-order reflection and transmission coefficients.

H65] Pulsating flow of unsteady immiscible viscous fluid flow under the combined effects of the smooth and corrugated wall of the channel

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This study deals with finding the exact solutions of the flow of unsteady immiscible viscous fluid under a general oscillatory time-dependent pressure gradient in a channel composed of a smooth and corrugated wall. The combined effects of the grooves and flat wall of the channel on the fluid flow are investigated using the Pulsatile flow between surfaces. At the interface, continuity of velocities and shear stresses is assumed. The unsteady flow depends upon the Reynolds numbers of the fluids. It is observed, that the velocity oscillates with the same frequency as the pressure gradient. Analytical expressions are provided for the mass flow rate and wall shearing stresses. Numerical results are presented. The corrugation grooves are used to enhance the efficiency of transport processes.

H66] A Two-Dimensional Model of Particle Motion in a Curved Channel Flow

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In this work a two-phase model is utilized to model interaction of both fluid phase and particle phase. The Basset-Boussinesq-Oseen (BBO) equation is modified to analyse particle motion in a curved microfluidic conduit subjected to external forces like Stokes drag, virtual mass, Faxén, Basset, and gravity. It is assumed that the fluid motion affects particle motion and not vice versa, implying that the Navier–Stokes equation for fluid and BBO equation for particle have one way coupling. A perturbation method is employed to solve fluid equations and an in-house MATLAB code has been developed for tracing the Lagrangian particle paths in curved micro conduits. The particle motion and the mixing of a dilute group of particles behaviour in the curved micro conduit are examined for different emerged parameters.

H67] Cosmological Insights from Three Newly Reconstructed Deceleration Parameters with Observational Data

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This article introduces three novel parametrizations of the deceleration parameter (DP) to explore the cosmological scenario. The newly introduced parametric forms of the DP are physically plausible. We constrained the model parameters using a Markov Chain Monte Carlo (MCMC) method by utilizing a combined dataset of 31 cosmic chronometers (CC) data points, 26 non-correlated baryonic acoustic oscillations (BAO) points, and recently updated 1701 Pantheon+ data points from supernovae type Ia (SNeIa). To explore the kinematic behavior of the model, we analyze various aspects such as the transition from deceleration to acceleration, as well as the energy conditions. The current analysis of the three parametric models reveals that the Universe is currently in an accelerated phase, which is supported by the present values of the EoS parameter and the negative SEC behavior within specific redshift ranges for all three models. Additionally, all three parametric models meet the WEC, DEC, and NEC conditions across the entire range of redshift values. We use the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) model selection criteria to compare the performance of the models. Overall, this study offers valuable insights into the accelerating Universe.

H68] Effects of Magnetic Field on Peristaltic Transport of a Micropolar Fluid through Porous Medium

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The present paper is envisioned for exploring the mathematical model for Micropolar Fluid model with nanoparticle in tube propagated by peristalsis. The governing two-dimensional equations illustrating the fluid flow are first transformed to make dimensionless and then the exact results were obtained. Lubrication theory approximations are used. Expressions for temperature, concentration, velocity, average flux, pressure drop, coefficient of heat and mass transfer are computed. Streamlines are plotted against pertinent parameters. Also computed streamlines plots to illustrate trapping phenomenon and bolus dynamics to characterise peristaltic propulsion. This paper focuses on presenting the broad range of applications that involve nanofluids, emphasizing their improved heat transfer properties that are controllable. These nanofluids have unique properties that make them suitable for such applications. Applications of the study include peristaltic micropumps and novel drug delivery systems in pharmacological engineering.

H69] Flat FRW cosmological models in f(Q) theory of gravitation

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In the present article, we have studied the Flat FRW space time with domain wall and Holographic dark energy in f(Q) theory of gravity for anisotropic fluid. The exact solutions of the field equations are obtained using the two different form of varying deceleration parameters (i) $q = -b(t) - 1$ and (ii) $q(t) = -lt - m - 1$. We also discuss the effect holographic dark energy on domain walls. Furthermore, we have also discussed some physical parameters of the investigated model for physical concern.

H70] Effect of Anisotropic Permeability on the Blink-Induced Motion of a Soft Contact Lens on the Eye

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The motion of a soft, permeable contact lens during a blink by the applied lid force is analyzed. The lens is considered to be porous in nature, having anisotropic permeability. We assume that during the blinking, eyelids are completely in contact with the lens. We model the squeezing and sliding of a contact lens underlying a post-lens tear film. The pre-lens tear film is neglected. We assume the flow inside the lens is governed by the Darcy equation and by the Navier-Stokes equation inside the post-lens tear film. We use the lubrication approximation to derive the thin-film evolution equation. We aim to examine how the morphology and microstructure of the lens affect its motion. We assume that the lens is anisotropic with permeabilities K2 and K1 along the principal axes, and the principal axis with permeability K2 makes an angle θ with the horizontal direction. The effect of the anisotropic permeability of the contact lens is discussed in detail. In addition, the influence of slip coefficient, lens thickness, and gravity on the squeezing and sliding motion of the contact lens is also discussed. The analysis presented can be applied to select a suitable composition of lens material to attain adequate oxygen supply to the corneal surface.

H71] Thermal nonequilibrium porous convection in a heat generating rectangular enclosure

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Post accident heat removal (PAHR), design of porous insulation for a nuclear power reactor core and heat transfer from chips via porous metal foams are just few wherein thermal natural convection occurs in porous media. Accurate description of fluid flow behavior in the porous media is essential to the successful design and operation of equipments in these areas. The aim of the present work is to study the influence of heat generation on natural convection flow in a rectangular cavity filled with a fluid-saturated porous medium by considering Darcy-Brinkman-Forchheimer model and by adopting a two-temperature model of heat transfer. The governing equations are solved using the finite volume technique with staggered grid formulation. The influence of the non-dimensional parameters such as aspect ratio A, heat transfer coefficient H and fluid-to-solid conductivity ratio on the resulting heat transfer characteristics are analyzed.

Section I : Mathematical Modelling, Bio-Mathematics, Operations Research

I1] Optimality Conditions for Multi-Objective Interval-Valued Optimization Problem on Hadamard Manifolds

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The KKT optimality conditions for multi-objective interval-valued optimization problem on Hadamard manifold are studied in this paper. Several concepts of Pareto optimal solutions, considered under LU and CW ordering on the class of all closed intervals in R, are given. The KKT conditions are presented under the notions of convexity, pseudoconvexity and generalized Hukuhara directional dierentiability. We show, with the help of an example, that the results done in this paper for solving multiobjective interval-valued optimization problems on Hadamard spaces are more general than the existing ones on Euclidean spaces. The main results are supported by examples.

15] Analysing the Performance of a Ferrouid Squeeze lm in Curved Rough Annular Plates with Slip eect: A Jenkins Model Approach

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This paper has undertaken a comprehensive investigation to assess the impact of slip velocity on ferrofluid lubrication based on the Jenkins model within a squeeze film situated between curved rough annular plates. In this study, the upper surface of the film is defined by a hyperbolic function, while the lower surface is determined by a secant function expression. To analyze the effect of surface roughness, Christensen and Tonder's stochastic model employed and incorporate Beavers and Joseph's slip model to examine the influence of slip velocity. The pressure distribution is determined by solving the associated stochastically averaged Reynolds-type equation, which allows to calculate the load-carrying capacity. The findings, presented graphically, confirm that transverse roughness generally has a detrimental impact on the system, but magnetization significantly enhances the load-carrying capacity. The investigation highlights the potential of the Jenkins model-based ferrofluid lubrication to mitigate the adverse effects of transverse roughness. However, to achieve improved performance characteristics, it is essential to reduce the slip parameter. Additionally, this manuscript emphasizes the critical role of the aspect ratio, particularly when dealing with higher negative skewness and variance values, even when appropriately selecting curvature parameters.

17] Analytical Expression for the Model that Describes the Heterogeneous Reaction-Diffusion Process with Immobilized Enzyme (Penicillin G Acylase)

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This research article examines the reaction-diffusion process in an immobilized enzyme batch reactor. The model incorporates strongly non-linear factors that are associated with standard Michaelis-Menten kinetics. The non-linear reaction-diffusion equations for substrate and product concentrations have been approximated analytically. Employing two different semianalytical methods, Akbari-Ganji's method (AGM) and the modified Adomian decomposition method (MADM), to compute the dimensionless steady-state solutions to the system of nonlinear differential equations for all values of reaction parameters. In addition, the dynamics of the mean integrated effectiveness factor of penicillin acylase in porous spherical particles have been presented for the determination of the local effectiveness factor. In order to gauge the potency of our proposed solution, we compare two semi-analytical results with a numerical result that are in good agreement across the whole concentration range. The proposed formulation aims to simulate the dynamic performance of the system utilizing the parameters and would enhance the determination of the optimum particle size for enzyme catalysts.

I8] Modelling Co-infection and Super-infection of HBV-HDV with Lyapunov Stability and Holling Type-II Treatment Rate

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Undoubtedly co-infection and super-infection by hepatitis B virus and hepatitis D virus (HBV-HDV) are severer liver diseases, which cause rapid progression toward liver cancer. Many researchers have studied them and introduced mathematical models focusing on different factors. In this paper we combined both co-infection and super-infection in one frame as a mathematical model in consideration with real dynamics of the disease and some assumptions, as well as we incorporated Holling type-II functional response as treatment function. Furthermore positivity and boundedness of the model have been deliberated, basic reproduction number at disease free equilibrium point has been computed, local stability has been explored using Jacobian matrix of the model and global stability has been investigated with the help of Lyapunov function. For supporting qualitative results we performed numerical analysis and concluded that both co-infection and super-infection are very infectious, they can cause new infections faster and almost all the susceptible individuals can be infected. However, the infection can be controlled via vaccination and treatment, among these two prevention measures, vaccination has great impact and is very effective compared to treatment against the disease.

I9] An Analytical Approach with RDTM for Bioheat Transfer in Human Skin Tissues During Sauna Therapy Treatment

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Heat transfer has an many applications in medical as well as engineering field. Several authors have been done their research work with respect to the applications of heat transfer theory. One of them is Sauna therapy. Sauna therapy have been around for a long time and are still well-liked worldwide. Infrared rays enter the body during an infrared sauna treatment, gradually raising body temperature. Sweat glands are the primary means of eliminating undesirable substances during sauna therapy. This work presents a mathematical approach of bioheat transfer in human skin tissues. A mathematical model that explains the heat transmission in human skin tissues during sinusoidal heating in sauna therapy. The recent mathematical techniques named as reduced differential transform method(RDTM) has been used to solve the mathematical problem. The thermal stresses have been studied theoretically and explain the nature of the temperature distribution of skin tissues during therapy by Python graphs. Also, the graphic representation of the thermal damage to skin tissues during sauna treatment is provided.

I10] Exact Solution of the Riemann Problem for a Two-Layered Blood Flow Model in Arteries

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Our main goal is to find an exact solution to the Riemann problem for two-layer blood flow model, where each layer has equal constant density and varied velocities. We investigate the fundamental waves, specifically the shock, rarefaction, and contact discontinuity waves, utilizing the approach of characteristics. We prove this solution exists locally and is unique by carefully examining three simple waves: the shock wave, contact discontinuity wave, and rarefaction wave. The solutions for every possible combination of waves are derived using the two-variable Newton-Raphson approach by taking the arithmetic mean of the original data. Finally, we use figures to simultaneously depict the variables.

I11] On Relationships Between Vector Variational Inequalities and Vector Optimization Problem Using Convexificators on Hadamard Manifold

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An important concept of convexificators has been extended to Hadamard manifolds in this paper. The mean value theorem for convexificators on Hadamard manifold has been also been derived. Monotonicity of the bounded convexificators has been discussed and an important characterization for the bounded convexificators to be ∂^*_*-geodesic convexity has been derived. Furthermore, a vector variational inequalities problem using convexificators on Hadamard manifold has been considered. In addition, the necessary and sufficient conditions for vector optimization problem in terms of Stampacchia and Minty ∂^*_*-VVIP has been derived.

I12] An Inventory Model for Controllable Deteriorating Items Having Power Pattern Demand under Preservation Technology Investment

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In this paper, we have described an inventory model for deteriorating items under preservation technology having power-pattern demand with trade credit facility and shortages. Here, we have introduced an interesting factor, that is, preservation technology to reduce the deterioration rate. Shortages are allowed with a backlogging rate depending on waiting time. Also, in this paper, we have introduced a trade credit policy from the perspective of retailers. Our main objective is to find the cycle length, preservation technology strategies, and total profit. Further, the imprecise parameters in a fuzzy environment are measured by triangular fuzzy numbers and the resulting fuzzy total cost functions are defuzzified by the Graded Mean Integration Representation (GMIR) Method. Moreover, several numerical examples are illustrated to justify our findings. Lastly, managerial insights are proposed after investigating the sensitivity behavior of various key parameters.

I13] Retailer's Inventory Model having Power Pattern Demand with Amelioration under Imprecise Costs

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In this paper, we devise an inventory model for the retailer's problems for the items with constant deterioration rate as well as of weibull ameliorating pattern having power demand under shortages. We first considered the model in the crisp environment having the deterministic parameters, such as, holding cost, rate of deterioration, and amelioration cost. Subsequently, to deal with the real-world situations, we have modelled this problem in the fuzzy environment having impreciseness in the above-mentioned parameters. In particular, we have considered the impreciseness in holding cost, deterioration rate, and amelioration cost as triangular fuzzy numbers, and used Graded Mean Integration Representation (GMIR) Method for defuzzification. We have proposed a general approach to obtain the optimal strategy for the proposed inventory problem in both the environments. Finally, several numerical examples are illustrated to justify the findings. Lastly, managerial insights are proposed after carefully investigating the sensitivity behavior of various associated key parameters.

I14] A Multiphase Model to Investigate the Impacts of HDL on Early Atherosclerosis

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Atherosclerosis is a chronic inflammatory disease of the cardiovascular system that primarily involves macrophages and foam cells forming early plaque within blood vessels. We introduce a multiphase model to investigate the influence of high-density lipoprotein (HDL) when oxidized low-density lipoprotein (oxLDL) and cytokines (in particular, monocyte chemoattractant protein-1) play a pivotal role in the development of early atherosclerotic plaque. The study delves into the mechanisms by which HDL facilitates reverse cholesterol transport (RCT), removing cholesterol from foam cells and its antioxidant properties, inhibiting the oxidation of low-density lipoprotein (LDL). Numerical simulations are performed on the governing multiphasic equations, and a tractable analytical approach for a non-trivial solution is employed to support the numerical findings. Parameter sensitivity analysis is done here to show that the influx parameters corresponding to oxLDL and cytokines positively correlate with plaque development, while HDL has a negative correlation. Our findings reveal that plaque width growth is not linear over time; it is high initially and gradually decreases, with the curve becoming less steep due to the influence of HDL. The elevation of both the HDL influx parameter and the parameter corresponding to the mediation of HDL in oxLDL influx leads to a declination in plaque growth. However, these parameters show a dual role in influencing the average oxLDL concentration within the intima. A comprehensive analysis of this model gives insights into the various biochemical and cellular mechanisms underlying early plaque development and the role of HDL in it.

I15] Two-phase Modelling of Microbial Pneumonia

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Microbial pneumonia is an inflammation of one or both lungs caused by microbes that affect the tiny air sacs called alveoli, which become inflamed and filled fully or partially with pus that disrupts the oxygen and carbon dioxide gas exchange during respiration. This study develops a two-dimensional model to describe the respiratory gas exchange process under an inflamed situation using three fluid layers representing a capillary blood flow, a pus layer inside an alveolus, and an airspace above the pus within the alveolus. The capillary blood has a biphasic description where blood plasma is assumed to behave as a Newtonian fluid, and RBCs show a shear-thinning nature. Besides, the pus layer exhibits a linear viscous flow. Perturbation approximation is applied to simplify the hydrodynamic equations, effectively reducing their complexity. This study investigates the effect of pus depth within an alveolus on the transportation of oxygen from the alveolus to the capillary. The advection-diffusion process governs the oxygen transport within the pus and capillary region. Pus accumulation reduces the partial pressure of oxygen within the alveolus, which decreases the pressure gradients between the alveolus and the capillary. As the pus accumulation increases, the reduction in pressure difference becomes more prominent. The reduction in alveolar oxygen concentration impacts the oxygen diffusion from the air into the bloodstream.

I16] Mathematical Modelling on the Activity of Biomarkers inside Arteries under Atherosclerosis

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Atherosclerosis, a chronic inflammatory cardiovascular disease, leads to arterial constriction caused by the accumulation of lipids, cholesterol, and various substances within artery walls. Such plaque can rupture, resulting in a blood clot that obstructs major arteries and may initiate myocardial infarction, brain strokes, etc. Early plaque comprises foam cells and macrophages, which stabilize due to the migration of smooth muscle cells (SMCs) from deeper layers of the artery wall to form a fibrous cap. Subsequently, the enlarged plaque gradually enters the lumen to obstruct blood flow. A two-phase model is introduced to investigate the progression of plaque growth in its advanced stage and analyze the minimum gap (clearance) within an atherosclerotic artery so that blood cells can easily pass through. Cardiac troponin, a biomarker with high specificity and sensitivity, facilitates early detection of elevated risks of heart attack or stroke. This study aims to establish a correlation between the troponin concentration in atherosclerotic arteries and their clearance. Based on our observations, we have found that the plaque evolves rapidly in the initial stages but gradually slows down over time. Moreover, the relationship between clearance and plaque evolution time displays an opposite behaviour, which means that the clearance decreases slowly in the early stages, and the rate of decrease increases as time progresses. Our study indicates a positive correlation between plaque length and troponin concentration in the blood, along with a negative relationship between troponin concentration and the clearance in atherosclerotic arteries.

I17] Electrophoretic Migration of a Charged Spheroid in a Brinkman Media

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Nanoparticle gel electrophoresis has been proven to be one of the most efficient techniques in the field of biomedical engineering towards anti-cancer drug delivery, medical imaging, nucleic acids separation process, etc. This study explores the flow behaviour of a colloidal charged particle of spheroid geometrical shape immersed in a polyelectrolyte that behaves like a Brinkman medium. The forthcoming analysis aims to assess the electrophoretic mobility of the charged particle through an analytical approach, like the regular perturbation method. The approximate expression of the shape of the colloidal charged nanoparticle is given by $r = 1+\epsilon * g_1(\theta)+\epsilon^2 * g_2(\theta)$,where ϵ is the small deformation parameter. The current study discusses how the shape and size of nanoparticles, electro-mechanical properties of polyelectrolytes,and various parameters impact electrophoretic mobility.

I18] Pontryagin's Minimum Principle in Optimal Control Problems

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The Pontryagin's minimum principle in control problems are developed with the help of the Hamiltonian functional to obtain the necessary optimality conditions in fractional control problems. The Caputo fractional derivatives and integrals are considered to prove these conditions. An example is also given to validate the fresh findings.

I19] Taylor Series Expansion for Functions of Several Variables Using Caputo Fractional derivatives.

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Using Caputo's fractional derivative, a Taylor's series expansion at lower limit a, upper limit b and at any point $x_0 \in (a, b]$, the subset of real numbers, are obtained for function of several variables. The Mond-Weir type duality model is formulated taking first two terms from Taylor's series expansions. Further, several numerical examples are given to verify the new finding.

I20] Higher Order Duality in Non-linear Programming Problems

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The importance of higher-order duality in non-linear programming problems are studied. It has been observed that third-order duality gives tighter bounds over the lower orders. Several numerical examples are discussed to justify the results.

I21] Third Order Symmetric Duality in Nonlinear programming problems

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The third order symmetric duality is formulated, where the involved objective and constraints functions are not restricted to linear. Required duality results are stated between the pair of third order symmetric dual problems. Several numerical examples are discussed to validate the new findings. It is also observed that some of the previously reported results are particular cases of the present investigations.

I22] Heat Transfer Analysis of MHD Casson Fluid Flow Between Two Porous Plates with Different Permeability

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Present study describes the Casson fluid flow between two porous plates with permeability criteria in the presence of heat transfer and magnetic effect. A proper set of similarity transformations simplify the Navier-Stokes equations to non-linear ODEs with boundary conditions. Semi-analytical solution is obtained using homotopy perturbation method and compared with the solution computed through an effective and efficient finite difference approach. Analysis of various physical parameters on the fluid flow velocity, temperature profile, heat transfer rate, and skin friction at the upper and lower plate by using both methods are displayed in the form of figures and tables. The semi-analytical solution obtained is in good agreement with the numerical solution.

I23] An EOQ Model of Deteriorating Items with Inflation-induced Dynamic Demand in an Imprecise Planning Horizon

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The degree of freshness is a crucial factor in driving the demand for perishable goods. The quality of a product diminishes with time, resulting in a subsequent decline in consumer demand. In light of prevailing conditions, sellers typically employ strategies such as gradually reducing the unit selling price over time and implementing various credit policies to stimulate demand. Various aspects, such as weather conditions, preservation techniques, storage environment and seasonal variations influence the deterioration of an item. Consequently, it is not possible to estimate a crisp estimation of the deterioration rate. So, it is preferable to define this parameter as a fuzzy parameter. This paper investigates the retailer's flow and inventory status of such a product with fuzzy deterioration rate, exponentially decaying dynamic unit selling price dependent demand under time-dependent trade credit policy. The formulation of the model incorporates fuzzy differential equations and fuzzy Riemann integration techniques, allowing for the estimation of the total fuzzy profit across the planning horizon. As the optimization of any fuzzy objective is not yet properly defined, a fuzzy goal of the problem is determined and the credibility measure of the fuzzy objective with respect to that fuzzy goal is optimized for the optimal marketing decision. A mixed-mode Particle Swarm Optimization strategy is proposed to address the problem that encompasses both real and integer variables. The model is examined in three different scenarios, each utilizing crisp, fuzzy and rough data sets. Some managerial insights are given and various sets of hypothetical data are used in various situations.

I24] Analyzing the Productivity in Cultivation of Major Rabi Crops in India using NSGA-III

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The present work focuses on analyzing the productivity of a many objective optimization problem of major Rabi crops in India using NSGA-III algorithm. The problem is predominantly formulated based on some actual data, encompassing the area and production quantities of 7 major Rabi crops in 18 states of India for the year 2020-21. It is addressed through the evolutionary algorithm of NSGA-III which involves generating a population of solutions using Vogel approximation inspired random initialization followed by NSGA-III procedure. The results in the form of Pareto optimal solutions obtained from this work are compared with the actual data of production quantities and area of cultivation for each state and each Rabi crop cultivated in 2020-21 using graphical illustrations.

I25] Impact of Limited Liability on Leveraged Risk for a Loan Portfolio

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The genesis of this presentation is the observation that banks enjoy limited liability in case of bankruptcy and/or insolvency and are accordingly required to maintain discipline in their risk management practices, including restrictions on the extent to which they can be leveraged. For the purpose of modeling, we consider a model (akin to the firm-value model of Merton), where the bank raises capital through equity and debt (deposits). For the simple model under consideration, we assume that the bank's loan portfolio comprises three assets, namely, a risk-free, a less risky and a more risky loan. For the optimization, we consider two problems (one with limited liability and the other without limited liability) of maximizing the expected return with a cap on the risk (which in our case is taken as the expected loss). The other two problems (again with and without limited liability) looks at the problem form the perspective of minimization of the risk, with a lower bound on the expected return. We have proved theoretically (and illustrate numerically) that the model(s) which include limited liability produce more desirable results, from the investors' perspective, as compared to the case of without the inclusion of limited liability. In particular, we obtain the key result that the optimized portfolio for the model with limited liability is less riskier than the optimized portfolio without limited liability.

I26] Exact Riemann Solution and Interaction of Elementary Waves for Two-layered Blood Flow Model in Collapsible Tube: Artery

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This work centers on the Riemann problem concerning a two-layered blood flow model. The model is expressed through a system of quasi-linear hyperbolic partial differential equations (PDEs), derived from the Euler equations through vertical averaging across each layer. We take into account the Riemann problem through arteries with different velocities and same constant density. Because of the blood vessel's viscous effect, the flow layer near the vessel wall, for example, has a slower average speed than the layer further from the vessel. We first prove the existence and uniqueness of the associated Riemann solution by carefully examining the characteristics of the three elementary waves: contact discontinuity, shock, and rarefaction. Moreover, we provide a thorough analysis of the rarefaction wave and shock wave elementary wave interaction with contact discontinuity. Finally, an explicit construction and graphical illustration of the global structure of the Riemann solutions following each wave interaction are provided.

I28] Community Transmission of Multiple HIV Strains under Treatment: A Mathematical Modelling Approach

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In this study, we propose a two-strain non-linear mathematical model comprising drug-sensitive and drug-resistant strains for the dynamics of Human Immunodeficiency Virus (HIV) spread in a community. A treatment compartment is included in the modelling framework by considering drug adherence. The next-generation matrix approach was used to determine the basic reproduction number for both the strains. Both the treatment-free, as well as the treatment model are analyzed. A comprehensive stability and bifurcation analysis of existing equilibrium points reveal the impact of treatment availability and adherence, on the spread of HIV and its multiple mutated strains. In the absence of treatment, one of the strains is likely to undergo competitive exclusion, whereas the introduction of treatment enables the possibility of the coexistence of both the strains. The system also shows periodic behaviour leading to the existence of a stable limit cycle.

I29] Traffic Flow Modeling in a van der Waals Gas: Exploring Riemann Problem and Weak Shock Wave Interactions

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This study examines the Riemann problem concerning a traffic flow model incorporating two velocities within a van der Waals gas. Through characteristic analysis, we ascertain the Riemann solution for simple waves, shock waves, and contact discontinuity waves. Furthermore, we showcase the method's precision in handling a family of elementary wave curves characterized by a single parameter. Additionally, we establish a general conclusion affirming the existence and uniqueness of a solution. We delineate necessary and sufficient conditions to ensure the presence of simple or shock waves for both one and three-family features within the initial data. Lastly, the study investigates the interaction between two shocks.

I30] The Riemann Problem and Interactions Between Weak Shock Waves for a Two-layer Blood Flow Model in Arteries and Veins

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In this study, we examine the interactions between two weak shocks of the Riemann problem in a two-layer blood flow model with each layer has the same density but different velocities in arteries and vein. This model considered the vertical averages across each layer. For example, due to the viscous effect from blood vessel, the flow layer near the vessel has slower averaged speed than the layer away from the vessel. The explicit form analytically derives from the shock, contact discontinuities and rarefaction waves. We have explicitly derived a family of elementary wave curves that depend on only one parameter. In our analysis, we have determined a necessary and sufficient condition for a shock wave or a rarefaction wave. This condition applies to both a 1-family and a 3-family of characteristics and it is based on the initial data of the solution of the Riemann problem. Finally, we show von Neumann's conclusion about combining two weak shocks from the same family.

I31] Steady State Analysis of a Machining Model with Emergency Vacation and Retention of Reneged Machines

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The main objective of this study is to investigate the impact of emergency vacation on a machine repair queuing model with single vacation policy. In emergency vacation, the server immediately leaves the system without finishing the ongoing repair. This kind of vacation cannot be predicted and the occurrence of it has to be examined critically to ensure the seamless operation of machine repair process. Additionally, we incorporate the concepts of reneging and retention to make it more relatable to the real-world scenario. The stationary state probabilities are obtained by implementing the matrix recursive method. Various performance metrics of the system are derived and analysed. Furthermore, the impact of different system parameters on the performance measures is examined.

I32] A Novel Study on Fractional Order Four Dimensional Chaotic System with Sliding Mode Chaos Control Technique

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Across many academic fields, the study of chaotic systems is beneficial because it offers basic understandings of complicated dynamics. In this work, we introduce a new four-dimensional chaotic system. The dynamics of this system are studied under the Caputo fractional derivative. The dynamical aspects like, dissipation, existence and uniqueness of the solution, equilibrium points, linear stability, Lyapunov exponents and sensitivity is analyzed. We have attained two differnt sliding mode controller to dominance the chaos in this system. The efficacy of the controller is monitored in the presence of external disturbances and uncertainty for both commensurate and incommensurate systems. Numerical simulation is performed with suitable values of parameter at which the system behaves like chaotic. Then the theoretical results are validated with the help of numerical simulation.

I33] Symmetry-Adapted U(2) Lie Algebras: A Comprehensive Exploration of Sixth Excitation Vibrational Frequencies in Gas-Phase Silanes

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This research employs the symmetry-adapted one-dimensional framework of U(2) Lie algebras to meticulously estimate silanes' sixth excitation vibrational frequencies in the gas phase. The chosen silanes bear spectroscopic relevance to terrestrial volcanic plumes and planetary atmospheres. A vibrational Hamiltonian is crafted to uphold the Td point group symmetry intrinsic to each silane molecule in developing a predictive model. This Hamiltonian is intricately constructed by integrating ten interacting Morse oscillator-bound state spectra, facilitating a comprehensive representation of the vibrational landscape. The study focuses on elucidating the vibrational characteristics of silanes, which are essential for understanding their behavior in diverse environments such as terrestrial volcanic plumes and planetary atmospheres. The proposed methodology extends the capabilities of symmetry-adapted one-dimensional U(2) Lie algebras to encompass the intricate nuances of sixth excitation vibrational frequencies, presenting a valuable contribution to molecular spectroscopy and theoretical chemistry.

I34] Studying Naphthalene's Fourth Overtone Vibrational Frequencies with the One-Dimensional Lie Algebraic Model

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This research paper introduces a novel exploration into vibrational frequencies by calculating the fourth overtone of Naphthalene (C 10 H 8), a polycyclic aromatic compound. This study employs the one-dimensional Lie algebraic model for the first time to unravel the complex vibrational characteristics of naphthalene. Known as the most successful computational tool in analysing and interpreting experimental vibrational spectra in polyatomic molecules, this model capitalizes on dynamical symmetry expressed through unitary Lie algebras. The constructed model Hamiltonian, characterized by its reliance on only four parameters, is remarkably effective in accurately describing the vibrational modes associated with C-H and C-C bonds. With the assistance of the one-dimensional Lie algebraic model, this method paves the way for a deeper comprehension of the vibrational dynamics of naphthalene, providing valuable insights into its molecular intricacies. The outcomes of this research contribute not only to the specific analysis of naphthalene but also to the broader field of vibrational spectroscopy and computational chemistry.

I35] The Use of Teaching Learning Materials in Teaching Mathematics and Its Influence on Students' Performance

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The role of TLMs in the classroom are to make learning real, practical and fun for children also help in bringing novelty and freshness in classroom teaching as it relieves learners from anxiety, fear and boredom and enable 21st century teachers to easily deliver the content/problem solving. The present study aims to examine the effects of the use of different teaching learning materials like visual, audio and audiovisual in teaching Mathematics in the educational institutions system and the study uses the secondary data. The results showed that the preferred teaching aids audiovisual are effective when compared to the visual and audio.

I36] Fractional Order Mathematical Model Of Criminal Gang Dynamics

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This research explores a novel approach to model crime transmission dynamics within the context of gang warfare using fractional differential equations. Crime is a complex and dynamics phenomenon influenced by a wide rang of factors, including social, economic and environmental variables. In this study we employ fractional calculus to capture non-local and memory-dependent behaviour inherent in crime propagation. The model's foundation lies in fractional differential equations, which provide a more accurate representation of real-world dynamics, as they allow for the inclusion of long-range interactions and past events influence. This research proposes model by categorizing the existing population into five clusters. The model shows equilibrium points (criminal-free and crime persistence equilibrium). The criminal-free equilibrium is globally asymptotically stable if criminal generation number less than one. The crime persistence equilibrium is locally asymptotically stable if criminal generation number greater than one. The well-posedness and stability of the proposed fractional model discussed in this work. Our finding shed light on the potential for utilizing this advanced model techniques to inform law enforcement strategies, social interventions, and public policies aimed at reducing gang-related crimes. By better understanding the intricate dynamics of crime transmission, we take a step towards a safer and more secure society.

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