



INDIAN



MATHEMATICAL



SOCIETY

## INDIAN MATHEMATICAL SOCIETY

(Founded in 1907; Reg. No. S-550, Delhi)  
Registered Office: Department of Mathematics,  
Savitribai Phule Pune University, Pune-411007

<http://www.indianmathsociety.org.in>

### NEWSLETTER

NO. 43

May 2020



Facsimile of the Commemorative Postage Stamp on the 'Indian Mathematical Society' issued by the Department of Posts (Philately Division, Government of India, to mark the completion of hundred years of the Society. Released on the Inaugural day of the Platinum Jubilee 75<sup>th</sup> Annual Conference of the Society on 27<sup>th</sup> December 2009.

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## A BRIEF REPORT OF THE 85<sup>th</sup> ANNUAL CONFERENCE OF THE IMS

The 85<sup>th</sup> Annual Conference of the Indian Mathematical Society was held at the Department of Mathematics, Indian Institute of Technology Kharagpur, Kharagpur (West Bengal) during November 22-25, 2019 under the president-ship of Prof. S. Arumugam, Department of Mathematics, Kalasalingam University, Anand Nagar, Krishnankoil (TN). The Conference was attended by more than 200 delegates. Two presidential addresses (General and Technical), one plenary talk by Prof Gadadhar Misra, IISc. Bangalore, Five Memorial Award lectures and six invited lectures were delivered in the conference. Also, six symposia were organized during the conference and thirty invited speakers gave talks in the symposia. Moreover, in all 160 research papers were accepted for presentation at the Conference including 14 research papers for the paper presentation competition for various prizes.

The Conference was inaugurated by Prof. Sriman Kumar Bhattacharyya, Director of IIT, Kharagpur. The function was presided over by Prof. S. Arumugam, the President of the IMS. Prof. G. P. Raja Sekhar, the Local Organizing Secretary of the Conference welcomed the delegates. The General Secretary of IMS, Prof. Satya Deo spoke about the Indian Mathematical Society and on behalf of the Society expressed his sincere and profuse thanks to the host for organizing the Conference. Prof. N. K. Thakare (Former General Secretary of IMS) was awarded the Life time achievement award for his valuable research in Mathematics and services to the IMS. Prof. J. R. Patadia was also felicitated for his devoted services to the IMS. Prof. Peeyush Chandra, the Academic Secretary of the IMS, reported the academic programmes of the Conference.

Prof. S. Arumugam delivered his the Presidential address (General) on “Applications of Linear Algebra to Physics and Computer Mathematics”. The function ended with a vote of thanks by Prof. Jitendra Kumar, Co-Organizing Secretary of the conference.

Prof. Arumugam gave his Presidential address (Technical) on “Coloring of Graphs” which was chaired over by Prof. N. K. Thakare, the senior most past president of the IMS present at that time.

Prof. Gadadhar Misra, IISc Bangalore, gave a **plenary talk** on “A product formula for homogeneous characteristic functions”.

The 33<sup>st</sup> **P. L. Bhatnagar Memorial Award Lecture** was delivered by Prof. Mythily Ramaswamy (TIFR, CAM) on “An invitation to Control of Differential equations”.

The 30<sup>th</sup> **V. Ramaswami Aiyar Memorial Award Lecture** was delivered by Prof Swagato K. Ray (ISI Kolkata) on “Quasianaliticity of functions and an uncertainty principle of Fourier analysis”.

The 30<sup>th</sup> **Srinivasa Ramanujan Memorial Award Lecture** was delivered-Prof Pratulananda Das (Jadavpur University) on “Non-negative summability matrices and ideals”.

The 30<sup>th</sup> **Hansraj Gupta Memorial Award Lecture** was delivered by Prof. Gurmeet Bakshi (Panjab University) on “Can we explicitly describe the structure of rational group algebras?”.

The 14<sup>th</sup> **Ganesh Prasad Memorial Award Lecture** was delivered by Prof. Kaushal Verma (I.I.Sc, Bangalore) on “An introduction to quadrature domains”.

Apart from the above lectures **Satish Bhatnagar Award Lecture** was delivered by Prof. K. Ramasubramaniam, IIT Bombay on “The art of weaving geometry and trigonometry with poetry : A study based on Nityanand’s Sarvasidhantraja”. **A. K. Agarwal Award Lecture** was given by Dr. G. Kasi Viswanadham on “Products of weighted multiple zeta functions”.

No papers were received or nominated this year for the year 2018 Prof. A. M. Mathai Award and so the Award has not been given to anyone.

P. L. Bhatnagar Memorial Prize for the top scorer in the Indian team which participated in the International Mathematical Olympiad (IMO) held at BATH, UK during July 11-22, 2019 is given to Pranjal Srivastava of National Public School, Koramangala, Bengaluru. He won a gold medal at the IMO.

Various prizes for the Paper Presentation Competition:

For the IMS prizes 14 papers were received : one in Group 1, two in Group 2, one in group 4, three in group 5, two in group 6, three for AMU Prize and two for V M Shah Prize. No paper was received for Group 3. The papers were presented in the competition section.

The following is the result for the award of these prizes.

**IMS Prize - Group-1:** One paper was presented in this group. The prize was awarded to Dr. Prashant P. Malvadkar, School of Mathematics, MIT World Peace University, Pune.

**IMS Prize - Group-2:** Two papers were presented in this group. The prize was awarded to Dr. Ganesh Kadu, Department of Mathematics, Savitribai Phule Pune University, Pune.

**IMS Prize - Group-3:** No paper was received in this group.

**IMS Prize - Group-4:** One papers was received and presented. However, the prize was not given to this paper.

**IMS Prize - Group-5:** Three papers were received in this group. But the prize was not awarded to anyone.

**IMS Prize - Group-6:** Two papers were received in this group. However, the prize was not awarded to anyone.

**AMU Prize:** Three papers were received in this group and the prize was awarded to Mr. Pankaj Gautam, Department of Mathematical Sciences, Indian Institute of Technology (BHU), Varanasi.

**V. M. Shah Prize:** Two papers were received and presented. The prize was

awarded to Mr. Chaitanya G. K., Department of Mathematical and Computational Sciences, National Institute of Technology Karnataka, Mangalore.

#### **Invited Lectures delivered**

Prof. Ramji Lal (Allahabad University) : Schur Multiplier and Milnor K-Theory.

Prof. Ashish Upadhyay (IIT Patna) : Centrally symmetric manifolds.

Prof. C. S. Dalawat (HRI, Prayagraj) : Two footnotes to Galioss Memoirs.

Prof. A Lakshmi Narayana (IIT Hyderabad) : Recent developments in matrix special function theory.

Prof. Rafikul Alam (IIT Guwahati) : Perturbation analysis of discrete spectra of analytic operator-valued functions.

Prof. Anand Srivastava (CAU Kiel Germany) : A New Bound for the Maker Breaker Triangle Game.

#### **Symposia organized**

Six symposia were organized and the details are as follows.

1. Group Theory.

Convener : Prof N S N Sastry (IIT Dharwad).

2. Theoretical and Computational Biology.

Convener : Prof P K Srivastava (IIT Patna).

3. Ramanujan and Mathematical Analysis.

Convener : Prof S Ahmad Ali (BBD University, Lucknow).

4. Combinatorics on Finite Sets.

Convener : Prof B. N. Waphare (S. P. Pune University, Pune).

5. Recent Trends in Differential Geometry.

Convener : Prof. M. M. Tripathi (BHU Varanasi).

6. Higher Mathematics Education in India.

Convener : Prof S. Kumaresan (IIT Kanpur).

There was also a session on **Student Meet** for school children in Kharagpur. The convener of the meet was prof G. P. Raja sekhar . Members on the panel Prof. Praveen Chaurasia, Prof. Somesh Kumar and Prof. G. P. Raja Sekhar.

**MINUTES OF THE 85<sup>th</sup> ANNUAL GENERAL BODY MEETING  
OF THE INDIAN MATHEMATICAL SOCIETY**

The 85th Annual General Body Meeting of the Indian Mathematical Society was held on Monday, the 25th November, 2019 at 12 noon in the Gargi Seminar Hall of IIT Kharagpur, West Bengal.

In the absence of the President, Prof. S. Arumugam, the General Secretary Prof. Satya Deo welcomed all the members present and took up the agenda items as follows:

**Item No. 1.**

To confirm the Minutes of the General Body meeting held on Friday, the 30th November, 2018 at 12 noon in the Meeting Hall of Shri Mata Vaishno Devi University, Katra, Jammu and Kashmir under the presidentship of Prof. Sudhir Ghorpade.

Since no comments were received from any member of the Society, the Minutes of the General Body meeting held on November 30, 2018 at 12 noon at Shri Mata Vaishno Devi University, Jammu and Kashmir were confirmed.

**Item No. 2:**

To receive the report of the General Secretary, Prof Satya Deo.

Report of the General Secretary:

- (i) The IMS Newsletter No 41 of March 2019 (prepared by Prof N. K. Thakare, the retiring GS) was sent to all members of the IMS and uploaded on our website. The Newsletter No. 42 of August, 2019 was finalized by the General Secretary Prof Satya Deo with the help of the Administrative Secretary Prof. B. N. Waphare. These newsletters were uploaded on the IMS website by Prof J. R. Patadia. The soft copies of the newsletters were sent to all members of the Indian Mathematical Society. Announcements of various Memorial Prize winners as well as the IMS Award winners of 2019 were made as soon as possible and they were uploaded on the IMS website for the benefit of members of the IMS and others.
- (ii) The meeting of the Academic Planning Committee (APC) of the IMS was held at the Department of Mathematics, S. P. University, Pune on June 9, 2019 from 11 am onward. All the necessary arrangements were made by the Administrative Secretary Prof. Waphare. The meeting was presided by the President of IMS Prof. S. Arumugam and all members (except the past President Prof. Sudhir Ghorpade, who was abroad) including Prof. Raja Sekhar, were present. The names of the five memorial Award lecturers, plenary speakers and conveners of various symposia were finalized. The academic secretary was requested to send invitation letters to all concerned and if some changes were needed, he was authorized to contact alternatives in consultation with the General Secretary Prof. Satya Deo and finalize.
- (iii) The General Secretary kept constant touch with the local organizing secretary Prof. Raja Sekhar and the Academic Secretary Prof. Peeyush Chandra for providing any kind of help/guidance requested by them.
- (iv) Narasinga Rao Memorial Prize: A committee consisting of Prof. Peeyush Chandra (convener), Prof. Sudhir Ghorpade, Prof. M. M. Shikare was constituted to recommend the Narasinga Rao Memorial Prize for the best paper published in the JIMS or MS in the year 2018. In the absence of

Prof. Sudhir Ghorpade, Prof. Shriram Nimbhorkar was also included in the committee. The committee, compelled by the terms and conditions of the prize, recommended that none of the papers were found suitable for the prize and so the prize has not been given to anyone this year. A committee to review the terms and conditions of this prize has been constituted by the IMS Council so that the prize is given to someone for his/her best paper.

- (v) P. L. Bhatnagar Memorial Prize: The prize for this year has been given to the top scorer of the Indian Team of International Math Olympiad Mr Pranjali Srivastava of Bangalore, who also won a gold medal in the competition. The IMO was held at BATH, UK during July 11-22, 2019. A letter was sent to Pranjali Srivastava requesting him to be present during the inaugural function of the annual session of IMS at IIT, Kharagpur. He accepted the award and informed that he will come to receive the prize. However, he fell ill at the eleventh hour due to the viral fever and could not come.
- (vi) A. K. Agarwal Award: For this Award, only two applications were received. One of the applications was in an applied mathematics area, and according to the terms of the award, that paper cannot be considered. The other paper was in number theory. Three referees were appointed to evaluate this paper and all of them recommended that the paper is quite suitable for the award. Accordingly, Dr G. Kashi Viswanadham of IISER, Berhampur, Odissa has been awarded the A. K. Agarwal Award of 2019 for his paper entitled Products of weighted multiple zeta functions published in Bulletin des Sciences Mathematiques, Vol 147 (2018) pp 26-39. A letter was sent to him giving this information and also asking him to be present during the annual session of the IMS at Kharagpur. He accepted the award and informed that he will come to the annual session to accept the award, and he participated in the conference and made a presentation on his paper.
- (vii) A. M. Mathai Award: No papers were received or nominated this year for this Award and so the Award has not been given to anyone. A letter received from Prof. Mathai in this connection was placed before the Council. The Council decided that the same committee as for Narsingarao prize, will also suggest ways so that there are enough applications for this award and the prize is given to someone for the best paper
- (viii) Satish Bhatnagar Award: This year, only one joint paper was nominated by Prof Amartya Datta of ISI, Kolkata. Prof S. G. Dani, Prof M. D. Srinivas and Prof R. Sridharan were appointed referees to see if the paper is really of exceptional quality for the Satish Bhatnagar Award. All of them stated that the paper is exceptionally outstanding and recommended both the mathematicians for the joint award. Accordingly, the Award has been given to Profs C. Montelle and K. Ramasubramaniam jointly on their paper entitled Determining the Sine of one degree in the Sarvasidhantraja of Nityanand published in SCIAMVS, Vol. 19(2018)pp. 1-52. The winners of the award were informed and both the professors wrote back accepting the award. Prof. Ramasubramaniam indicated that he will come to the annual session of the IMS to receive the award, and he participated in the conference and made a presentation on his paper.
- (ix) During this period more than 138 life members and about 40 sessional members were enrolled for the IMS conference at IIT, Kharagpur. This information was given by the treasurer of IMS and the local secretary of the IMS respectively.

- (x) I am in constant touch with Prof. J. R. Patadia to update, maintain and improve the IMS website. The website has the unique permanent ID of every member along with his/her name and the place. Other details of the member like the address, email and phone etc. is not uploaded to keep their privacy intact.
- (xi) The old proposal of the IMS for having a piece of land for its permanent headquarters in Pune got a good start this year. Office bearers based at Pune namely, Prof. M. M. Shikare and Prof. B. N. Waphare, under the guidance of Prof. N. K. Thakare, searched and found a suitable plot for the IMS headquarter. Prof. Peeyush Chandra and Prof. Nimbhorkar also visited the plot site. This matter has been considered in detail in the Council of the IMS and a suitable decision has been made to purchase the land. The initial agreement for the purchase of the plot measuring about 32,000 sq.ft. at the approximate cost of Rs 1,60,00,000=00 has been signed and an advance of Rs 6 lakhs has also been paid.

**Acknowledgements:**

The General Secretary thanks Prof. B. N. Waphare, the Administrative Secretary, for his help in the preparation of IMS Newsletters. He also thanks Prof J. R. Patadia for maintaining the IMS website and uploading newsletters and various other announcements of the IMS from time to time.

**Item No. 3 :** To receive the Report of the Academic Secretary, Prof Peeyush Chandra:

Report of the Academic Secretary.

Based on the deliberations during the APC meeting held on June 9, 2019 at SP Pune University, Pune and subsequent consultations with the General Secretary following speakers have been finalized.

**Plenary Speaker:** Prof. Gadadhar Misra(I. I. Sc. Bangalore) : A Product Formula for Homogeneous Characteristic Functions

**Memorial Award Lectures:**

33rd P. L. Bhatnagar memorial Award Lecture: Prof. Mythily Ramaswamy(TIFR, CAM) : An invitation to Control of Differential equations

30th Hansraj Gupta Memorial Award Lecture: Prof. Gurmeet Bakshi (Panjab University) : Can we explicitly describe the structure of rational group algebras?

30th Ramanujan Memorial Award Lecture: Prof. Pratulananda Das(Jadavpur University) : Non-negative summability matrices and ideals

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14th Ganesh Prasad Memorial Award Lecture: Prof. Kaushal Verma(I.I.Sc, Bangalore) : An introduction to quadrature domains

**Invited speakers:**

Prof. Ramji Lal (Allahabad University) : Schur Multiplier and Milnor K-Theory.

Prof. Ashish Upadhyay(IIT Patna) : Centrally symmetric manifolds.

Prof. C. S. Dalawat(HRI, Prayagraj) : Two footnotes to Galioss Memoirs.

Prof. A Lakshmi Narayana (IIT Hyderabad) : Recent developments in matrix special function theory.

Prof. Rafikul Alam(IIT Guwahati) : Perturbation analysis of discrete spectra of



analytic operator-valued functions.

Prof. Anand Srivastava(CAU Kiel Germany) : A New Bound for the Maker Breaker Triangle Game.

### **Symposia**

#### 1. Group Theory

Convener : Prof. N S N Sastry (IIT Dharwad)

Speakers : K. N. Raghavan, IMSc, Chennai, Anupam Kumar Singh, IISER, Pune, Shripad M. Garge, IIT, Bombay, Manoj Kumar Yadav, HRI Allahabad, Ravindra Prasad Shukla, Allahabad, University, N S N Sastry IIT Dharwad

#### 2. Theoretical and Computational Biology

Convener : Prof. P K Srivastava (IIT Patna)

Speakers : Malay Banerjee, IIT Kanpur, A. K.Misra, BHU Varanasi, Pranay Goel, IISER Pune, BSRV Prasad, VIT Vellore, P K Srivastava, IIT Patna.

#### 3. Ramanujan and Mathematical Analysis

Convener : Prof. S Ahmad Ali (BBD University, Lucknow)

Speakers : A. K. Agarwal, Punjab University, M. A. Pathan A M U, Aligarh , Kalyan Chakraborty, HRI Prayagraj, Atul Dixit I I T, Gandhinagar, S. Ahmad Ali, BBD University, Lucknow.

#### 4. Combinatorics on Finite Sets

Convener : Prof. B. N. Waphare (S. P. Pune University, Pune)

Speakers : S. Sivaramakrishnan IIT, Bombay, Anirban Banerjee, IISER Kolkata, M. M. Pawar, SSVPS Dr. P. R. Ghogare Science College, Dhule, Vinayak Joshi, S. P. Pune University, V. S. Kharat S P Pune University, B. N. Waphare, S. P. Pune University.

#### 5. Recent Trends in Differential Geometry

Convener : Prof. M M Tripathi (BHU Varanasi))

Speakers : M Hasan Shahid, Jamia Milia Islamia University, New Delhi, Shiv Sharma Shukla, Univ of Allahabad, D G Prakasha, Davangere Univ. Davangere, Gauree Shanker Central University of Panjab, Bhatinda, M M Tripathi, BHU, Varanasi.

#### 6. Higher Mathematics Education in India

Convener : Prof. S. Kumaresan(IIT Kanpur)

Speakers : B K Sarma IIT Guwahati, Ajit Kumar ICT Mumbai, Sudhir Ghorpade IIT Bombay, V Sholapurkar SP College Pune, S Kumaresan IIT Kanpur.

The Conveners for various symposia have finalized the speakers in each case. An event of School Children Meet is going to be organized this year with Prof G P Raja Sekhar as coordinator.

This year total of 160 papers have been received out of which 14 papers are for Prizes (3 for AMU Prize, 2 for V M Shah prize, 1 for Gr 1, 2 for Gr 2, 1 for Gr 4, 3 for Gr 5 and 2 for Gr 6), Apart from it about Five papers had been rejected. No paper was received for Posters this year.

I am thankful to the General Secretary for his suggestions at various stages in finalizing the speakers.

**Item No. 4:** To consider the Audited Statement of Accounts for the year 2018-2019 and budget for the year 2020-2021.

The Audited Statement of Accounts for the year 2018-2019 and budget for the year 2020-2021 presented by the Treasurer, Prof. S. K. Nimbhorkar were approved.

**Item No. 5.** To receive the report of the Editor, Prof Sudhir Ghorpade, the Journal of the Indian Mathematical Society for 2019. Report of the Editor, the Journal of the Indian Mathematical Society for 2019.

**Manuscript status:**

(a) Number of manuscripts pending with the referees/ under process at the end of 2018 :	20
(b) Number of manuscripts received during 2019:	80
Total:	<hr/> 100
(a) Number of manuscripts accepted in 2019:	20
(c) Number of manuscripts not accepted in 2019	20
(d) Number of manuscripts with the referees/ under process:	60
Total:	<hr/> 100

**Publication Status (online by the IPL)**

(a) Volume 86 (1-2) 2019 of the JIMS was published in November 2018. (b) Volume 86 (3-4) 2019 of the JIMS was published on July 1, 2019. (c) Volume 87 (1-2) 2020 of the JIMS is expected to be published online in January 2020. Publication Status (Print by the IMS) (a) Volume 86 (1-2) 2019 of the JIMS was published in Dec-Jan 2019 and has been sent to the subscribers. (b) Volume 86 (3-4) 2019 of the JIMS is now published and it is being sent to the subscribers by the Administrative Secretary, IMS in November-December 2019. (c) Volume 87 (1-2) 2020 of the JIMS is expected to be published in February 2020.

**Acknowledgements:**

The Chief Editor, JIMS expresses his sincere thanks to numerous referees and the members of the Editorial Board, JIMS, especially Prof Peeyush Chandra and Prof. Ravi Agarwal, for their help in refereeing and/or processing the manuscripts received for JIMS. He also records his sincere thanks to Prof. B. N. Waphare for extending all possible help in printing and dispatching copies of the JIMS to the subscribers of the Journal. He is also very grateful to Prof. Satya Deo for able guidance and to Prof. Shriram Nimbhorkar for excellent overall help in various matters related to the JIMS.

**Item No. 6:** To receive the report of the Editor of The Mathematics Student for 2019, Prof M. M. Shkare

Report of the Editor of the Mathematics Student for 2019.

### **Publication Status of the Journal**

The Volume 88 (Nos. 1-2) January-June, 2019 of the Mathematics Student has been published in June 2019. The soft copy of the issue is sent to all the life members of the IMS by e-mail. The camera ready copy of Volume 88 (Nos. 3-4) July-December, 2019 of the Mathematics Student is ready and is forwarded to Parshuram Process, Pune for printing it out. The printing will be completed by first week of December 2019. The soft copy of this issue will be sent to the life members of the IMS by e-mail soon. The soft copies of both the issues have been uploaded on the website of the Indian Mathematical Society.

### **Status of the Manuscripts**

In all 60 research papers have been received by the Chief Editor for publication in the Mathematics Student till November 14, 2019. Out of these 60 research papers, 23 papers have been accepted for publication in the journal, 17 papers were not accepted, 15 papers are pending with referees and 5 papers are under process.

### **Status of the Journal**

Recently the University Grants Commission (UGC) has included the Mathematics Student in the list of the UGC approved journals. Attempts are being made to bring the journal in the list of Scopus Indexed Journals. Scopus is Elseviers abstract and citation database launched in 2004. We have received the indication that the Mathematics Student will get this status in a short period of time.

### **Digitization of Back Volumes**

We propose to digitize the back volumes of the Mathematics Student with the help of Informatics Publishing Limited, Bangalore. The back volumes of the journal can be made available from the IMS library, Chennai and the Library of the Savitribai Phule Pune University, Pune.

### **Acknowledgements**

We take this opportunity to put on record our sincere thanks and profuse gratefulness to the Members of the Editorial Board and the learned referees for their continuous support and assistance in our sustained efforts for timely publication of the Mathematics Student. We would like to thank Prof. George E. Andrews, Prof. M. Ram Murty and Prof. B. Sury for proposing Problems for the Problem section, verifying solutions received from researchers and providing solutions to unsolved problems.

We are grateful to Prof. J. R. Patadia for typesetting the papers and sending soft copies of the journal to the life members of the IMS and the General Secretary Prof. Satya Deo for reading the camera ready copies of the issues carefully. We are also thankful to the Administrative Secretary Prof. B. N. Waphare for getting the issues printed from Parshuram Process, Pune and preserving the hard copies

of the journal in the library of the Mathematics Department of S. P. Pune University, Pune. (PS. : On 25/11/2019 we received an e-mail from the Scopus Title Evaluation Team stating that The review of the Mathematics Student by Content Selection and Advisory Board (CSAB) is complete and the CSAB has advised that the Mathematics Student will be accepted for inclusion in Scopus. **This is really a great achievement.**)

**Item 7.** To consider the venue of the 86th Annual session of the Society to be held in December 2020.

There were four proposals to host the next annual conference of the IMS. The Council accepted the firm invitation from the Registrar (Director), Vellore Institute of Technology (VIT), Vellore, Tamil Nadu, for organizing the 86th Annual Conference of the Indian Mathematical Society. The 86th Annual Conference of the IMS will be held at VIT, Vellore, Tamil Nadu during December 17-20, 2020. Prof. Rushi Kumar, Head, Department of Mathematics, VIT, Vellore will be the Local Organizing Secretary of the conference. Suitable regret letters will be sent to the remaining organizations thanking them for their proposals to host the annual session of the IMS

**Item 8.** Announcement of the results of the following elections.

- (i) President for 2020-2021;
- (ii) Three members of the Council for a period of three years w. e. f. April 01, 2020.

Returning officer Prof. Waphare reported as follows.

The Council of the Indian Mathematical Society (IMS), at its meeting held in November 2018 at Shri Mata Vaishno Devi University, Katra, Jammu and Kashmir made the following nominations to the Office of the President of the Society and to the Council of the IMS.

The Office of the President :

The Council nominated Prof. B. Sury, Theoretical Stat. And Math. Unit, Indian Statistical Institute, Bangalore for election to the Office of the President of the Society with effect from April 01, 2020. No other nominations have been received from the members of the IMS for election to the office of the President. **Therefore no election was held and Prof. B. Sury is declared elected unopposed to the office of the President of the IMS for one year with effect from April 01, 2020.**

Election of members to the Council of the Society :

The Council made the following nominations as members of the Council of the Society with effect from April 01, 2020 for three years.

1. Prof. A. K. Das (Shri Mata Vaishno Devi University, Katra, Jammu).
2. Prof. N. D. Baruah (Department of Mathematical Sciences, Tezpur University, Assam).
3. Prof. G. P. Youvaraj (Ramanujan Institute for Advanced Study in Mathematics, Uni. of Madras, Chennai).

**Item 9.** Any other item with the permission of the chair.

No other item was under consideration.

The efforts put in by the Local organizing Secretary Prof. G. P. Raja Sekhar, his colleagues and the IIT Kharagpur administration for successful organization of the conference were appreciated by the office bearers and the members of the IMS.

The Meeting ended with a vote of thanks to the Chair and members of the IMS, Prof. G. P. Raja Sekhar, his colleagues and the IIT Kharagpur administration.

Satya Deo  
General Secretary  
Indian Mathematical Society

### IMS Sponsored Lectures

To popularize mathematics and to create awareness regarding the Society and its activities in the Country, the Society has a Scheme of **Sponsored Lectures**. It provides a token support of Rs. 1000/- to a number of Departments / Institutions for organizing popular and semi technical lectures.

Prof. Ravi Kulkarni has also donated Rs. 1,25,000/- to organize **Meenakshisundaram–Patoudi lectures**.

Members arranging such lectures are required to send the report of the arranged lectures to The Treasurer, IMS, with a copy to The Editor, **The Mathematics Student**.

*Society intends to enhance this activity of organizing such lectures at more and more centers. Members desirous to organize such lectures at their centers may write to the General Secretary Prof. Satya Deo through their respective Head of the Department.*

### Periodicals published by the Society

The Society publishes two periodicals: **The Journal of the Indian Mathematical Society** (JIMS; the Journal; Print ISSN 0019-5839, Online ISSN 2455-6475 ) and **The Mathematics Student** (Math Student; the Mathematics Student; Print ISSN 0025-5742), both of which are quarterly. The details can be found on the website: [www.indianmathsociety.org.in](http://www.indianmathsociety.org.in)

### Subscriptions

Annual subscription for the Journal / the Mathematics Student :

For each periodical

- Rs. 2000/- for Libraries of Educational Institutions in India - provided the subscription is direct or through an agent who gives complete name and address of the subscriber. The supply will be made directly to the subscribing library. If an agent subscribes for an educational Institution in India, the subscription is Rs. 2500/-
- Rs. 10000/- for others for personal use or to the agents who do not supply the name and address of the end user.
- \$200/- for personal use or for Libraries outside India.

The agents are entitled to 15 % discount on their orders.

From the 2012 issue of **The Mathematics Student** onwards, the life Members are given online access to **The Mathematics Student** / are sent the soft copy of **The Mathematics Student**, instead of supplying the hard copy, for their personal use (not for circulation) at their E-mail address registered with the Society.

**Those Members who have not registered their e-mail address are requested to register it online on [msgoesgreen@gmail.com](mailto:msgoesgreen@gmail.com)**

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There will not be any further institution of Memorial Award Lectures. (This point was discussed in the earlier meetings of the Council and such was the consensus).

The donation amount will not be less than Rupees Five Lacs. (There could be an upward revision of this amount from time to time).

The donor may be an individual or a trust or a group of individuals.

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The invited speaker(s) will be the guest of the host institution. In case of an honorarium, if any, to the invited speaker, the amount of the honorarium will not exceed the honorarium amount for the existing Memorial Award Lectures.

Ordinarily train travel to the extent of AC-2 Tier be reimbursed. However, in special cases the domestic air travel may be considered.

Notwithstanding the above,

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The Council reserves its right whether or not a particular donation be accepted.

### **An Appeal to all members of the IMS**

As a part of the “Green Initiative ”taken by the Society (for further details, refer Society’s website [www.indianmathsociety.org.in](http://www.indianmathsociety.org.in) ), the Council of the Society has decided to send online the soft copy of the Mathematics Student / give online access to the Mathematics Student to all the Life members instead of supplying the hard copy. For this purpose, all the members of the Society are requested to register their e-mail address online, along with Name and the **Unique Membership Number** therein, to Prof. J. R. Patadia on e-mail **imsgoesgreen@gmail.com** or **jamanadaspat@gmail.com** so that further necessary action can be taken.

#### **Important Change:**

Beginning from the 84<sup>th</sup> annual conference of the IMS the abstract of the papers accepted for presentation and invited talks etc. are being published in our newsletter and this policy will continue in future also. Such abstract will no longer be published in the Mathematics Student..



## Abstracts of the papers presented at the 85<sup>th</sup> IMS Conference, IIT, Kharagpur, West Bengal

### Plenary Talk

A product formula for homogeneous characteristic functions by Gadadhar Misra Department of Mathematics Indian Institute of Science, Bangalore 560012 gm@iisc.ac.in

A bounded linear operator  $T$  on a Hilbert space is said to be homogeneous if  $\varphi(T)$  is unitarily equivalent to  $T$  for all  $\varphi$  in the group Möb of bi-holomorphic automorphisms of the unit disc. A projective unitary representation  $\sigma$  of Möb is said to be associated with an operator  $T$  if  $\varphi(T) = \sigma(\varphi)^* T \sigma(\varphi)$  for all  $\varphi$  in Möb.

In this talk, we discuss a Möbius equivariant version of the Sz.-Nagy–Foias model theory for completely non-unitary (cnu) contractions. As an application, we prove that if  $T$  is a cnu contraction with associated (projective unitary) representation  $\sigma$ , then there is a unique projective unitary representation  $\hat{\sigma}$ , extending  $\sigma$ , associated with the minimal unitary dilation of  $T$ . The representation  $\hat{\sigma}$  is given in terms of  $\sigma$  by the formula

$$\hat{\sigma} = (\pi \otimes D_1^+) \oplus \sigma \oplus (\pi_* \otimes D_1^-),$$

where  $D_1^\pm$  are the two Discrete series representations (one holomorphic and the other anti-holomorphic) living on the Hardy space  $H^2(\mathbb{D})$ , and  $\pi, \pi_*$  are representations of Möb living on the two defect spaces of  $T$  defined explicitly in terms of  $\sigma$ .

Moreover, a cnu contraction  $T$  has an associated representation if and only if its Sz.-Nagy–Foias characteristic function  $\theta_T$  has the product form  $\theta_T(z) = \pi_*(\varphi_z)^* \theta_T(0) \pi(\varphi_z)$ ,  $z \in \mathbb{D}$ , where  $\varphi_z$  is the involution in Möb mapping  $z$  to 0. We obtain a concrete realization of this product formula for a large subclass of homogeneous cnu contractions from the Cowen-Douglas class.

This talk is based on the joint work with Bhaskar Bagchi and Somnath Hazra.

## Memorial Award Lectures

### 33<sup>rd</sup> P L Bhatnagar Memorial Award Lecture

An Invitation to Control of Differential Equations by Mythily Ramaswamy Chennai Mathematical Institute, Chennai mythily@cmi.ac.in

After introducing the basic concepts of control theory for ordinary differential equations, we discuss the infinite dimensional analogue of partial differential equations, indicating the behaviors for different type of partial differential equations. The example of a mixed parabolic-hyperbolic system, modeling compressible fluids will be indicated.

### 30<sup>th</sup> Hansraj Gupta Memorial Award Lecture

Can we explicitly describe the structure of rational group algebras? by Gurmeet K. Bakshi Centre for Advanced Study in Mathematics Panjab University, Chandigarh 160014, India gkbakshi@pu.ac.in

It is a classical problem to determine the primitive central idempotents (pcis) and the Wedderburn decomposition of a rational group algebra  $\mathbb{Q}G$ . This problem has relevance to other problems in group rings and coding theory. The classical method of computing pcis involves the knowledge of the character table of  $G$  and does not bring the subgroup structure of  $G$  into picture. It also does not give any insight into the structure of the corresponding simple components of  $\mathbb{Q}G$ . In 2004, Olivieri, del Río and Simón introduced a powerful character free method and proved that these computations can be efficiently done for strongly monomial groups (in particular abelian by supersolvable groups). In this talk we will show that the method of Olivieri, del Río and Simón can be extended

for a very large class of monomial groups, which we call as generalized strongly monomial groups. This is a natural but a non trivial generalization. We'll show that the class of generalized strongly monomial groups is vast, and rather so vast that it is difficult to construct an example of a monomial group which is not generalized strongly monomial.

### 30<sup>th</sup> V. Ramaswamy Aiyer Memorial Award Lecture

Quasianaliticity of functions and the decay of Fourier transform by Swagato K. Ray Stat-Math Unit, Indian Statistical Institute, Kolkata swagato@isical.ac.in

It is a well known fact of Harmonic Analysis that very rapid decay of the Fourier transform of an integrable function, on Euclidean spaces, imposes real analyticity on the function. Consequently, such functions cannot vanish on nonempty open sets. In the context of real line, classical results of N. Levinson and A. E. Ingham characterized the decay of the Fourier transform which prohibits a nonzero function to vanish on nonempty open subsets. For instance, the following result was proved by N. Levinson: Suppose  $f \in L^1(\mathbb{R})$  and  $\psi : [0, \infty) \rightarrow [0, \infty)$  is such that

$$\int_1^\infty \frac{\psi(|x|)}{x^2} dx = \infty.$$

If  $f$  vanishes on a nonempty open subset of  $\mathbb{R}$  then it vanishes identically.

Results of this genre are related to the classical Denjoy-Carleman theorem regarding characterization of quasianalytic functions on  $\mathbb{R}$ . In this lecture we will talk about extension of a Denjoy-Carleman type theorem and the results of N. Levinson and A. E. Ingham to Riemannian symmetric spaces of noncompact type which are generalizations of hyperbolic spaces.

### 30<sup>th</sup> Srinivasa Ramanujan Memorial Award Lecture

Non-negative summability matrices and ideals by Pratulananda Das Department of Mathematics, Jadavpur University, Kolkata - 700032 pratulananda@yahoo.co.in

Historically non-negative summability matrices  $A = (a_{jk})$ , in particular non-negative regular matrices have played important role in the field of Summability Theory and Convergence of Sequences. The idea of ideals were introduced (Kostyrko, Salat, Wilczynsky, Real Anal. Exchange, 2001) to extend the notion of several types of convergence in 2001 and over the next eighteen years it has been seen that analytic  $P$ -ideals play a very important role in the development of the theory. Analytic  $P$ -ideals have always also played a major role in descriptive set theory. In 1999 S. Solecki in his seminal paper, characterized these ideals as exhaustive sets  $Exh(\varphi)$  of lower semicontinuous submeasures  $\varphi$  on  $\omega$ . Subsequently using a weight function  $g$  depend on  $\omega$ , Balcerzak, Das, Filipczak, Swaczina have shown that one can generate uncountably many different analytic  $P$ -ideals using different functions  $g$  (Acta Math. Hungarica, 2015) using Solecki's characterization by submeasure which was further extended in (Bose, Das, Kwela, Indag. Math., 2018). In both these cases the matrices corresponding to the density functions were not necessarily regular. Very recently Das, Filipow, Tryba have finally been able to describe ideals generated by non-regular positive matrices in the process disproving Connor's conjecture that only regular matrices can generate such ideals because they showed that one can generate an analytic  $P$ -ideal by a certain type of non-regular matrix which can not be generated by any regular matrix (Colloq. Math., 2019). We will discuss this whole development in this talk.

### 14<sup>th</sup> Ganesh Prasad Memorial Award Lecture

An introduction to quadrature domains by Kaushal Verma Department of Mathematics, Indian Institute of Science, Bangalore kverma@math.iisc.ernet.in

Quadrature domains are those on which integrable holomorphic functions satisfy a generalized mean value inequality. The purpose of this talk will be to discuss some of the remarkable properties that these domains possess.

## IMS Award Lectures

### A. K. Agarwal Award Lecture

Products of weighted multiple zeta functions by G. Kasi Viswanadham  
IISER Berhampur vissu35@gmail.com

We define the weighted multiple zeta functions which are certain variants of the usual multiple zeta functions. We characterise all the weighted multiple zeta functions whose products satisfy stuffle (shuffle) relation.

### Satish Bhatanagar Award Lecture

The art of weaving geometry and trigonometry with poetry: A study based on Nityānanda's Sarvasiddhāntarāja by K. Ramasubramanian Cell for Indian Science and Technology in Sanskrit Department of HSS, IIT Bombay mullaikramas@gmail.com

Scholarly investigations, particularly over the past few decades, on the history, philosophy and practice of mathematics across different cultures, has amply demonstrated that the 'muse of mathematics can be wooed in many different ways'. While it is granted that the practice has been widely different, nevertheless it is not so well known that mathematics can also be fused beautifully with poetry. Though in the ancient past, scholars in the Indian tradition had adopted the s.utra style of composition, most of the works in Indian astronomy or mathematics, after the 5th century ce, have been composed in metrical form. This was perhaps a conscious choice to make the medium of composition as beautiful as the content. Blending mathematics with beautiful poetry seems to be an art by itself. It is remarkable that this art has been perfected by scores of Indian astronomer-mathematicians like Sripati (11th cent.), Bhaskaracarya (12th cent), Nityananda (17th cent) and so on. They not only perfected, but have been exceedingly successful in taking this art to great heights. During the talk, by considering a few passages from Nityananda's Sarvasiddhantaraja, particularly dealing with the computation of sines, we would like to demonstrate how he has been able to intricately weave geometry and trigonometry into the fabric of beautiful poetry with great delicacy. Starting with the basic rules and relations for determining the sines, cosines, and versines of various arcs, we intend to take the audience through the double and half-angle formulae, as well as the demonstration of the formulae for sines of sums and differences of two angles, and finally end up with a discussion on the different techniques of computing the sine of one degree.

## Invited Talks

1. Perturbation analysis of discrete spectra of analytic operator-valued functions by Rafikul Alam, Department of Mathematics Indian Institute of Technology Guwahati, Guwahati-781 039, India rafik@iitg.ac.in

Let  $X$  be a complex Banach space and  $L(X)$  be the Banach space of all bounded linear operators on  $X$ . Let  $\Omega \subset \mathbb{C}$  be open and  $T : \Omega \rightarrow L(X)$  be analytic. The analytic eigenvalue problem is to solve  $T(\lambda)v = 0$  for  $\lambda \in \Omega$  and a nonzero vector  $v \in X$ . Consider the one parameter family of analytic operator-valued functions  $W(\lambda, t) :=$

$T(\lambda) + tV_1(\lambda) + t^2V_2(\lambda) + \dots$ , where  $t \in \mathbb{C}$  and  $V_j : \Omega \rightarrow L(X)$  is analytic for  $j \in \mathbb{N}$ . We analyze the discrete spectra of  $W(\lambda, t)$  when  $t$  varies in  $\mathbb{C}$ . We prove Rouché's theorem for the operator-valued function  $W(t, \lambda)$  under a weaker assumption which we utilize to prove the analyticity of a simple eigenvalue  $\mu(t)$  as well as the weighted average  $\mu_{\text{av}}(t)$  of a group of discrete eigenvalues of  $W(t, \lambda)$  and derive series expansions of  $\mu(t)$  and  $\mu_{\text{av}}(t)$  when  $|t|$  is sufficiently small. We also derive perturbation bounds for the discrete eigenvalues of  $W(\lambda, t)$  when  $|t|$  is small.

## 2. Two footnotes to Galois's Memoirs by Chandan Singh Dalawat, Harish-Chandra Research Institute, Allahabad dalawat@gmail.com

In his short life, Galois wrote two unpublished Memoirs. As an application of the theory he developed in the First Memoir, Galois gave a criterion for an equation of prime degree to be solvable by radicals. Using this criterion, we give a parametrisation of solvable extensions of prime degree. In his Second Memoir, Galois introduced the concept of primitivity and proved that if a primitive equation is solvable by radicals, then its degree is a prime power. We complement this result by parametrisation of all primitive solvable extensions of an arbitrary field. This parametrisation can be explicitly worked out in the important case of local fields. An effort will be made to make the talk accessible to a general mathematical audience, with no prior knowledge of algebra or arithmetic.

## 3. Centrally symmetric manifolds by Ashish Kumar Upadhyay, Department of Mathematics Indian Institute of Technology Patna upadhyay@iitp.ac.in

A polyhedral map  $M$  is a surface together with a finite simple graph embedded on it such that the boundary of the union of all the faces containing a vertex is topologically a circle. We call a polyhedral map  $M$  to be centrally symmetric if it remains invariant under the action of an involution on the set of its vertices and which fixes no face of  $M$ . Central symmetry has wide applications in mathematics. This talk is based on joint work with Dipendu Maity. In this talk we give a short survey on Centrally Symmetric Manifolds. Further we introduce some methods to construct centrally symmetric triangulated manifolds. In particular, we show the existence of some infinite series of centrally symmetric triangulated manifolds. We also present enumeration of centrally symmetric triangulated 2 and 3 dimensional manifolds with few vertices.

## 4. A New Bound for the Maker Breaker Triangle Game by Anand Srivastav, Department of Mathematics Christian-Albrechts Universität Kiel (Kiel University), Kiel, Germany srivastav@math.uni-kiel.de

The triangle game introduced by Chvátal and Erdős (1978) is one of the most famous combinatorial games. For  $n, q \in \mathbb{N}$ , the  $(n, q)$ -triangle game is played by two players, called Maker and Breaker, on the complete graph  $K_n$ . Alternately Maker claims one edge and thereafter Breaker claims  $q$  edges of the graph. Maker wins the game if he can claim all three edges of a triangle, otherwise Breaker wins. Chvátal and Erdős (1978) proved that for  $q < \sqrt{2n} + 2 - 5/2 \approx 1.414\sqrt{n}$  Maker has a winning strategy, and for  $q \geq 2\sqrt{n}$  Breaker has a winning strategy. Since then, the problem of finding the exact leading constant for the threshold bias of the triangle game has been one of the famous open problems in combinatorial game theory. In fact, the constant is not known for any graph with a cycle and we do not even know if such a constant exists. Balogh and Samotij (2011) slightly improved the Chvátal-Erdős constant for Breaker's winning strategy from 2 to 1.935 with a randomized approach. Since then no progress was made. In this work, we present a new deterministic strategy for Breaker's win whenever  $n$  is sufficiently large and  $q \geq \sqrt{(8/3 + o(1))n} \approx 1.633\sqrt{n}$ , significantly reducing the gap towards the lower bound. In previous strategies Breaker chooses his edges such that one node is part of the last edge chosen by Maker, whereas the remaining node is chosen more or less arbitrarily. In contrast, we introduce a suitable potential function on the set of nodes. This allows Breaker to pick edges that connect the most 'dangerous' nodes. The total potential of the

game may still increase, even for several turns, but finally Breaker's strategy prevents the total potential of the game from exceeding a critical level and leads to Breaker's win.

5. Nonlinear stability analysis of some flow problems in porous media by P. A. L. Narayana, Department of Mathematics, Indian Institute of Technology Hyderabad ananth@iith.ac.in

In this talk two problems will be addressed. In the first problem, we show that the global stability analysis using  $L^2$  functional gives fruitful results for Hadley-Prats flow in porous media, on the other hand the same approach fails to give global stability for the flows with viscosity stratified flows in porous media. To overcome this difficulty, we resort to another approach using the higher order norms to achieve the global stability of such flows.

6. Schur Multiplier and Milnor K-Theory by Ramji Lal, Harish-Chandra Research Institute, Allahabad mathrjl@gmail.com

The purpose of this talk will be to introduce a version of Schur Hopf formula for multiplicative Lie algebras and discuss its relationship with Milnor K-Theory, and in turn, with arithmetic.

## Symposia Talks

### Combinatorics on Finite Sets

1. Gamma positivity of the Excedance based Eulerian polynomial in  $\mathcal{A}_n$  by Sivaramakrishnan Sivasubramanian, Department of Mathematics, IIT Bombay krishnan@math.iitb.ac.in

For a positive integer  $n$ , let  $[n] = \{1, 2, \dots, n\}$  and let  $\mathfrak{S}_n$  be the set of permutations on  $[n]$ . For  $\pi = \pi_1, \pi_2, \dots, \pi_n \in \mathfrak{S}_n$ , define its number of excedances as  $\text{exc}(\pi) = |\{i \in [n] : \pi_i > i\}|$ . Let  $\mathcal{A}_n \subseteq \mathfrak{S}_n$  be the subset of even permutations. Define

$$\text{AExc}_n^+(t) = \sum_{\pi \in \mathfrak{S}_n} t^{\text{exc}(\pi)} \quad \text{AExc}_n^+(t) = \sum_{\pi \in \mathcal{A}_n} t^{\text{exc}(\pi)} \quad \text{and} \quad \text{AExc}_n^-(t) = \sum_{\pi \in \mathfrak{S}_n - \mathcal{A}_n} t^{\text{exc}(\pi)}$$

It is easy to see that the polynomial  $\text{AExc}_n(t)$  is palindromic and has degree  $n-1$ . Any degree- $d$  palindromic polynomial  $f(t)$  has center of symmetry  $d/2$  and can be written as a linear combination of the polynomials in the set  $\Gamma = \{t^i(1+t)^{d-2i} : 0 \leq i \leq d/2\}$ . If this expression for  $f(t)$  has all positive coefficients, then  $f(t)$  is said to be **gamma positive**. Foata and Schutzenberger showed that  $\text{AExc}_n(t)$  is gamma positive for all  $n$ .

We consider gamma positivity of positive and negative parts  $\text{AExc}_n^+(t)$  and  $\text{AExc}_n^-(t)$  defined above. Surprisingly there are no results on these polynomials. Two of our results are the following.

**Theorem 1.** For all positive integers  $n \geq 5$  with  $n \equiv 1 \pmod{2}$ ,  $\text{AExc}_n^+(s, t)$  and  $\text{AExc}_n^-(s, t)$  are gamma positive, with both polynomials having the same center of symmetry  $(n-1)/2$ .

**Theorem 2.** For all even positive integers  $n = 2m$  with  $n \geq 4$ ,  $\text{AExc}_n^+(t)$  and  $\text{AExc}_n^-(t)$  can be written as a sum of two gamma positive polynomials whose centers of symmetry differ by one.

We prove similar results when excedances are summed over the positive derangements. Most of our results can be generalised in the context of positive elements of Coxeter Groups. This is joint work with Hiranya Kishore Dey.

2. Spectral study of non-uniform hypergraphs by using matrices by Anirban Banerjee, Department of Mathematics & Statistics Indian Institute of Science

Education and Research Kolkata anirban.banerjee@iiserkol.ac.in

Here, we represent a non-uniform hypergraph by an underlying weighted graph and perform the spectral study on that graph to reveal different features of the hypergraph. We introduce different connectivity matrices, such as adjacency, Laplacian, and normalized Laplacian matrices on that weighted graph and show that various structural characteristics of non-uniform hypergraphs, like, diameter, vertex strong chromatic number, Cheeger constant, etc., can also be well studied using spectral properties of these matrices. Spectral radii of the same can be bounded by different parameters of a non-uniform hypergraph. With this approach, we also study random walk and Ricci curvature on a non-uniform hypergraph.

3. Adjunct operation of posets, colouring and enumeration by Madhukar M. Pawar, Department of Mathematics S. S. V. P. S's. L. K. Dr. P. R. Ghogrey Science College, Dhule m2pawar@yahoo.com

The aim of this lecture is to explain the concept of adjunct of posets introduced by Professor N. K. Thakare and his group. Using this novel concept of adjunct of lattices a structure theorem for dismantlable lattices is established.

One of the application of this theorem is to show that every dismantlable lattice is three colourable. It is also used to characterize two chromatic dismantlable lattices and this characterization helps us to classify the class of dismantlable lattices. Moreover, a co-relation between chromatic number of two posets and their adjunct is obtained.

Other application of the structure theorem is to enumerate non-isomorphic lattices of certain type.

4. Union-Closed Sets Conjecture - A lattice theoretic approach by Vinayak Joshi, Center for Advanced Study, Department of Mathematics Savitribai Phule Pune University, vvjoshi@unipune.ac.in

In 1979, Peter Frankl conjectured the following, known as the Union-Closed Sets Conjecture or Frankl's Conjecture.

**Union-Closed Sets Conjecture 1.** *Let  $\mathcal{F}$  be a collection of subsets of a finite set  $X$  such that  $F \cup G \in \mathcal{F}$  holds for all  $F, G \in \mathcal{F}$ , that is,  $\mathcal{F}$  is a union-closed family. If  $|\mathcal{F}| \geq 2$  then there is an element  $x$  in  $X$  such that at least  $|\mathcal{F}|/2$  members  $F \in \mathcal{F}$  satisfy  $x \in F$ .*

Despite its elementary statement, the Union-Closed Sets Conjecture is considered to be one of the difficult problems in extremal set theory. The conjecture remains unsolved, though some partial results have been obtained.

Mainly, two approaches were used to solve the conjecture, one using pure combinatorial arguments and second by the use of lattice theoretic methods.

Poonen [*Union-closed families*, J. Combin. Theory Ser. A **59**(1992), 253–268.] seems to be the first one who formulated the Conjecture in the language of lattice theory.

**Union-Closed Sets Conjecture (Lattice Theoretic Version) 1** (Poonen (1992)). *In every finite lattice  $L$  with  $|L| \geq 2$ , there is a join-irreducible element  $j$  (that is  $j = a \vee b \Rightarrow j = a$  or  $j = b$ ) such that  $|\{x \in L: j \leq x\}| \leq |L|/2$ .*

In this talk, we discuss the partial solutions of the Union-Closed Sets Conjecture via lattice theoretic methods.

5. Combinatorial Aspects of AFS Structures by Vilas Kharat, Center for Advanced Study, Department of Mathematics S. P. Pune University, Pune, India ladool1@yahoo.com

The structures of "EI Algebra generated by a finite set" is essentially a study using information attributes. Given a set  $M$  of simple concepts on a set  $X$ , the order of  $EM$  is the number of complex concepts generated by the simple concepts in  $M$ , which are not equivalent in the EI Algebra  $EM$ . In fact, if  $C_k(E, M)$  is the set of  $k$  length irreducible elements in  $EM$ , then order of  $EN$  can be evaluated with help of  $C_k(E, M)$ . By using the

Sperner class theory, the size of the longest fuzzy concept in  $EM$  can be determined.

## 6. On Spanning Subgraphs and Generalized Connectivity of Augmented Cubes, a Variation of Hypercubes by B.N. Waphare, Department of Mathematics, Savitribai Phule Pune University waphare@yahoo.com

The spanning trees  $T_1, T_2, \dots, T_n$  of a graph  $G$ , if exist, are edge-disjoint spanning trees (EDSTs) if they are pairwise edge-disjoint. Two spanning trees  $T_1, T_2$  in  $G$  are internally vertex disjoint if for any pair of vertices  $u$  and  $v$  of  $V(G)$ , the path in  $T_1$  from  $u$  to  $v$  and the path in  $T_2$  from  $u$  to  $v$  share only two vertices namely  $u$  and  $v$ . The spanning trees  $T_1, T_2, \dots, T_n$  of a graph  $G$ , if exist, are completely independent spanning trees (CISTs), if they are pairwise internally vertex disjoint. A set of  $m$  paths between  $u$  and  $v$  in  $G$ , do not contain the same vertex besides  $u$  and  $v$ , and their union covers all vertices of  $G$  is called  $m$ -disjoint path cover (m-DPC) in  $G$ . A graph  $G$  is one-to-one  $m$ -disjoint path coverable if there is an m-DPC between any two vertices of  $G$ . In a connected graph  $G$ , for a given set  $S \subseteq V(G)$  with at least two vertices, an  $S$ -Steiner tree is a subgraph  $T$  of  $G$  such that it is a tree with  $S \subseteq V(T)$ . For a given set  $S \subseteq V(G)$  and  $|S| \geq 2$ , the generalized local connectivity, denoted by  $\kappa_G(S)$ , is the maximum number of edge-disjoint and vertex-disjoint  $S$ -Steiner trees in  $G$ . The generalized  $k$ -connectivity of a graph  $G$ , denoted by  $\kappa_k(G)$ , is the minimum value of  $\kappa_G(S)$  when  $S$  runs over all  $k$ -subsets of  $V(G)$ . The hypercube is very popular interconnection network. Augmented cube is one of the important variations of hypercube due to its favorable properties, useful in routing algorithms and in fault tolerant systems. In this talk, we explore the concepts EDSTs, CISTs and conditional path covers in the augmented cube. We also see the generalized connectivity of augmented cube which we obtained by using its conditional path covers.

### Report on the Symposium Combinatorics on Finite Sets

The symposium was held in the Gargi Auditorium, IIT Kharagpur on 24<sup>th</sup> November, 2019 from 14.30 to 17.00 hours. As a convenor, B. N. Waphare introduced the speakers, gave highlights of the symposium and presented the recent developments in respect of spanning subgraphs and generalized connectivity of Hypercube structures.

After that five speakers gave talks.

1. Sivaramkrishnan Sivasubramanian, IIT Bombay, gave a talk on gamma positivity of the excedance based Eulerian polynomials in  $\mathcal{A}_n$  by way of giving nice connections of center of symmetries of these polynomials.
2. Anirban Banerjee, IISER Kolkata, talked on "The spectral study of non-uniform hypergraphs by using matrices." He presented spectral properties of various matrices associated with these hypergraphs and also the results related to random walk and Ricci curvature on a non-uniform hypergraph.
3. M. M. Pawar, P. R. Ghogre Science College, Dhule presented various techniques of colouring and enumeration of posets and dismantlable lattices using related structure theorem.
4. V. V. Joshi, S. P. Pune University gave the updated developments in respect of the various partial solutions of the famous long-standing "Union-closed sets conjecture" including its lattice theoretic version.
5. Lastly, Vilas Kharat from S. P. Pune University presented combinatorial aspects of AFS-structures. He highlighted applications of these structures in recent development of information technology and decision making theory. There were useful interactions among the speakers and the audience of the symposium.

## Group Theory

1. pi-systems in symmetrizable Kac-Moody Lie algebras by K.N. Raghavan, The Institute of Mathematical Sciences, Chennai knr@imsc.res.in

We will discuss the results (and the ideas behind their proofs) in the following paper: arXiv: 1902.06413, joint with Lisa Carbone, Biswajit Ransingh, Krishanu Roy, and Sankaran Viswanath. The notion of a pi-system goes back to Dynkin and comes up naturally in the investigation of regular imbeddings of semisimple Lie algebras in one another. The results, in part motivated by physics, are about the existence of pi-systems of certain types in a given Lie algebra and their conjugacy under the Weyl group action. We will recall the relevant definitions, provide context, and illustrate by means of simple examples in an attempt to make the talk accessible to a wide audience.

2. Word map on groups by Anupam Singh, IISER Pune, anupam@iiserpune.ac.in

Solving equations is a fundamental problem in Mathematics. We look at the equation  $w(X_1, \dots, X_n) = g$  where  $w$  is a monomial in the variables  $X_1, \dots, X_n$  for an element  $g$  in a group  $G$ . The surjectivity of word map over finite simple groups and quasi-simple groups has been one of the central problems in finite group theory in recent times. These are called Waring-like problems. Shalev and others computed bounds for  $|w(G)|/|G|$  when  $G$  is a finite simple group of Lie type and showed that the lower bound is  $c/n$  except for type  $A_n$  and  ${}^2A_n$ . He further conjectured that the same bound is expected for these cases as well. In this talk we present our exploration in this direction.

3. z-classes of reductive groups by Shripad M. Garge, Department of Mathematics, IIT Bombay shripad@math.iitb.ac.in

Two elements of a group  $G$  are called z-equivalent if their centralizers in  $G$  are conjugate in  $G$ , and the corresponding equivalence classes are called z-classes. In this talk, we shall review results regarding the z-classes of  $G(k)$  where  $G$  is a reductive linear algebraic group defined over a field  $k$ .

3. Finite groups with abelian automorphism groups by Manoj Kumar Yadav Harish-Chandra Research Institute, Prayagraj myadav@hri.res.in

Study of finite groups with abelian automorphism groups was initiated a century ago by G. A. Miller, who constructed examples of finite non-abelian 2-groups admitting abelian automorphism groups. For this reason, such groups are called Miller groups. It is an easy observation that non-abelian Miller groups are of nilpotency class 2. In spite of nilpotency class 2 and many rigorous attempts by several mathematicians, the structure of Miller groups is still a mystery. It is planned to present an extensive survey on the topic with some pointers to further possible directions of search.

4. Monster and its mysteries by N.S. Narasimha Sastry Department of Mathematics Indian Institute of Technology, Dharwad nnsastry@iitdh.ac.in

The discovery and the construction of the monster simple group is one of the last major components of the enormous and successful project classifying finite simple groups, a very major achievement of twentieth century mathematics. This enormous group with very intricate structure, manifests strikingly the sporadic (that is, the non-Lie theoretic) nature of simplicity of a finite group and ties together many exceptionally attractive mathematical objects (Golay codes, Leech lattice, extra-special groups, etc) and has deep connections with other areas of mathematics and physics (modular functions,  $(E_8)$  algebra, string theory, ...) I very briefly indicate some of these aspects and hope that it motivates for deeper understanding of this group.



### Report on the ‘Symposium on Group theory’

held on 24 Nov 2019 as a part of the 85th annual meeting of Indian Mathematical Society held at IIT, Kharagpur

There were five lectures, of half an hour duration each, in the Symposium on Group theory, held on 24 November 2019. All the lectures were on topics of current active research interest. Here is a brief description of the themes of the lectures:

Professor Anupam Kumar Singh (IISER, Pune) highlighted some of the current work on word problems and Waring type problems for finite simple groups and finite quasi simple groups by Larsen, Shalev and Tiep, as well as, his work with his collaborators.

Professor Shripad Garge (IIT, Bombay) introduced the concept of  $Z$ - classes (a variation of conjugacy classes) for a group and presented some structure revealing examples. He also indicated the proof of the finiteness of the number of classes in reductive algebraic groups over fields satisfying a mild arithmetic condition.

Professor Manoj Kumar Yadav (HRI, Prayag) discussed some significant results on the important topic of the automorphism groups of finite  $p$ -groups and highlighted the structure of finite  $p$ -groups whose automorphism group is abelian.

Professor K,N,Raghavan (IMSC, Chennai) introduced the concept of  $pi$ -systems in Symmetrized Kac-Moody algebras and indicated the uniqueness of the embedding, up to Weyl group conjugacy and negation, of the algebra  $A_1^{++}$  in  $E_{10}$  as well as its physical interpretation that Einstein’s gravity in 4-dimensions embeds canonically in 11-dimensional Super gravity;

Professor N.S.N.Sastry (IIT,Dharwad) explained the discovery of the amazing finite simple group, the Monster, as a final piece in the classification of finite simple groups; and indicated its connection to modular forms via Monster moonshine conjectures (due to Conway and Norton and proved by Borcherds) as well as to the affine  $E_8$ - root system observed by McKay.

-NSN Sastry (03-12-2019; IIT, Dharwad)

## Theoretical and Computational Biology

1. Nonlocal interacting population model with Neumann boundary condition: Turing and spatial Hopf instability by Malay Banerjee Department of Mathematics & Statistics, IIT Kanpur malayb@iitk.ac.in

Spatio-temporal pattern formation by reaction-diffusion models of interacting species is an active area of research to understand the self-organized heterogeneous distribution of population over their habitat. There is a good number of interacting population models which fail to satisfy the Turing instability conditions however the constituent species are known to produce stationary heterogeneous distribution. This stationary pattern forming scenario can be captured by considering nonlocal interaction, by modifying the reaction-diffusion model to integro-differential equations to model the nonlocal interaction. A good number of literature is available in this direction but the boundary conditions are assumed to be periodic for mathematical simplicity. In the context of ecology, no-flux boundary condition is a reasonable choice. The main objective of this presentation is to explore the effect of Neumann boundary condition on the resulting patterns produced by a prey-predator model with nonlocal interaction. The complicity of linear stability analysis to determine the Turing and spatial Hopf-bifurcation conditions will be discussed in detail. Sensitivity of the obtained results with the variation of kernel function will be addressed briefly.

2. Dynamics of infectious diseases: Effects of TV, radio and social media advertisements by A.K. Misra, Department of Mathematics, Institute of Science Banaras Hindu University, Varanasi akmisra.knp@yahoo.com

Public health information through media plays an important role to curb the spread of various infectious diseases as most of the populations rely on what media projects to them. Social media and TV and radio advertisements are important mediums to communicate

people regarding the spread of any infectious disease and methods to prevent its spread. They are widely acknowledged as important interventions in raising issues of public health care and play promising role to control the infection through propagating awareness among the individuals. Awareness which brings behavioral changes among the individuals can be seen as partial treatments at no cost. Apart from this, it also reduces the economic burden required for medication. In this talk, my main focus will be on the modelling the control of infectious diseases in presence of broadcasting the information through TV, radio and social media as dynamic variables. The susceptible population is assumed vulnerable to infection as well as information (through TV, radio and social media ads). It is assumed that the growth rate of advertisements is proportional to the number of infected individuals with decreasing function of aware individuals. The feasibility of possible equilibria, their stability properties, existence of Hopf-bifurcation and results for the direction of bifurcating periodic solutions are discussed. It is shown that the increment in growth rate of TV and social media ads destabilizes the system and periodic oscillations arise through Hopf-bifurcation. It is observed that TV and social media advertisements regarding the spread of infectious diseases have the potential to bring behavioral changes among the people and control the spread of diseases. Since radio is a cost-effective and responsive medium to disseminate the information among the communities. Therefore, a mathematical model is also proposed to see the interplay between impacts of TV and radio ads to control the infectious diseases in a variable size of population by considering equal importance of broadcasting the information through TV (specially for urban population) and radio (for rural population) as dynamic variables. In this case also, we analyzed the proposed model using stability theory of differential equations and numerical simulation. It is found that the increase in dissemination rate of awareness among susceptible population through TV and radio ads due to popularity of some new ads gives rise interesting dynamics about the stability of endemic equilibrium and causes stability switch through Hopf-bifurcation.

### 3. Oxidative stress and insulin secretion in type 2 diabetes by Pranay Goel, IISER Pune pgoel@iiserpune.ac.in

Diabetes is diagnosed as a persistent elevation in blood glucose. Insulin secretion is a very important aspect of the regulation of glucose homeostasis: An (eventual) insufficiency of insulin typically leads to the inability to clear glucose to normal levels. It is, however, debated what are the essential causal mechanisms that lead to the sequence of events resulting in the overt disease. We have postulated that oxidative stress, that is, an excess of reactive oxygen species produced during glucose metabolism, is the key to understanding not only diabetogenesis but also the complications of the disease. I will present some results of a clinical trial we have recently concluded on antioxidant supplementation in diabetes. We find that the supplementation group appears to do better in terms of glucose control, and suprisingly, in elderly diabetics insulin secretion was significantly increased. I will present a preliminary mathematical model that tries to explain these results in terms of the action of oxidants on insulin secretion. I will attempt to present a unified framework to describe the relationship of oxidative stress to insulin secretion in both the development of diabetes as well as its control. This is joint work with collaborators at Pune University, Jehangir Hospital and others.

### 4. Role of supplementary food resources on biological control efficiency of natural enemies: Theoretical perspectives by B.S.R.V. Prasad, School of Advanced Sciences, Vellore Institute of Technology srvprasad.bh@gmail.com

Modern agriculture methods are focusing on alternative and sustainable methods to overcome the detrimental impacts caused by chemical control of pests on the environment. One such service is biological control of pests by natural enemies such as predators, parasitoids and pathogens. It is well established that many biocontrol agents are a generalist in nature and depend on other plant-derived foods such as pollen, nectar. The complex

trophic interactions arising between natural enemy and pest viz., predation, competition, anti-predator behaviour of prey and conspecific predation in predators can hinder the goals of biological control. Understanding the role of supplementary foods on the life-history traits of biocontrol agents and their influence on the trophic interactions is essential to develop efficient pest control strategies to generate higher economic returns in agro-industry. Improving the availability of alternative hosts by the provision of supplementary resources to sustain natural enemies is a part of habitat management, a pivotal process to develop sustainable management systems. In the present work, we will explore the use of mathematical modelling in understanding the role of supplementary foods to enhance the biocontrol efficiency of predators under various trophic interactions. By using the theory of dynamical systems, we characterise the food supplements and derive the conditions under which, provision of food supplements help the predators to drive the pest below the economic threshold levels. These studies can aid eco managers to identify suitable food resources and time of release in a specific agro-ecological site.

**5. Oscillations and Stability Switches due to Delay in an Infectious Disease Model** by A. Kumar<sup>1</sup>, Y. Takeuchi<sup>2</sup>, P.K. Srivastava<sup>3</sup> <sup>1</sup>Thapar Institute of Engineering and Technology, Patiala <sup>2</sup>Aoyama Gakuin University, Kanagawa, Japan <sup>3</sup>Indian Institute of Technology Patna anujdubey17@gmail.com, takeuchi@gem.aoyama.ac.jp, and pksri@iitp.ac.in

A delay differential equation model for the dynamics of infectious disease is proposed and analyzed which accounts for the effect of disease information. As the information propagation is dependent on the prevalence of disease, the delay in reporting the prevalence is an important factor. Keeping this in mind, the dynamics of information with delay effect is modeled by a separate rate equation. Also, the time lag in waning immunity related with protective measures (such as vaccination, self protection, responsive behaviour etc.) is also accounted. It is proved that the disease free equilibrium exists unconditionally whereas the unique infected equilibrium is obtained when the basic reproduction number ( $R_0$ ) is greater than unity. When  $R_0 < 1$  and the rate of loss of total immunity is sufficiently small for the removed population, it is shown that the disease free equilibrium is locally stable irrespective of the effect of delays. On the other hand, when the rate is large, the disease free equilibrium is shown to become unstable for large time delay for waning of immunity. Whereas, when  $R_0 > 1$ , the model dynamics exhibits rich and complex dynamics in presence of time delays. Due to delay effect, model analysis accentuates the occurrence of oscillatory behaviour of the population around the infected equilibrium via Hopf bifurcation. The occurrence of Hopf-Hopf (double) bifurcation at two different delays for the model system is also investigated. At the first Hopf bifurcation threshold, the endemic equilibrium loses its stability, produces periodic orbits and then regains its stability at another Hopf bifurcation threshold. Hence, the delay effect in the model system causes multiple stability switches. Numerical experimentations are performed to analyze and support the obtained results.

### **Report on symposium Theoretical and Computational Biology**

A symposium on the Theoretical and Computational Biology was organized by Dr Prashant Kumar Srivastava of IIT Patna in the 85th IMS held at IIT Kharagpur. A group of senior and young researchers were invited to deliver talks related to the symposium. A wide spectrum of topics from ecology and epidemiology were covered by the speakers. These topics included (a) theoretical models in ecology - nonlocal interacting population models and role of supplementary food on biological control, (b) nonlinear dynamical models in epidemiology dealing with effect of media on disease dynamics and impact of time lags in disease models and (c) a model and data study on type 2 diabetes. The speakers included Dr Malay Banerjee (IIT Kanpur), Dr Arvind Kumar Misra (BHU Varanasi), Dr Pranay Goel (IISER Pune), Dr BSRV Prasad (VIT Vellore) and Dr Prashant Kumar Srivastava (IIT Patna). The session was well taken by audience. The

symposium showcased current advances in the area of theoretical and computational biology and provided awareness among the audience about the important interdisciplinary research area of mathematical biology.

## Ramanujan and Mathematical Analysis

1. Ramanujan-the legendary Indian mathematician of the twentieth century by A.K. Agarwal, Centre for Advanced Study in Mathematics, Panjab University, Chandigarh

Srinivasa Ramanujan was certainly the most influential Indian mathematician of the 20th century. He is a universally well known most charismatic mathematician with a standing and reputation such as only a very few other mathematicians have enjoyed. In this lecture we shall talk about some of his crowning mathematical achievements and their global impact.

2. On generalization of Taylor's series, Riemann zeta functions, (p,q)-Bernoulli-Hermite polynomials and formulas of Ramanujan by M.A. Pathan, Centre for Mathematical and Statistical Sciences, Thrissur Department of Mathematics, Aligarh Muslim University mapathan@gmail.com

Lidstone series is a generalization of Taylor's series. It approximates to a given function in the neighborhood of two points (instead of one). This series includes the polynomials later called Lidstone polynomials. Since our results of Hermite-Bernoulli polynomials can be connected to Riemann zeta functions, Bernoulli polynomials, Hermite number, Bernoulli-Hermite numbers and (p,q)-hypergeometric-Bernoulli polynomials, we can apply above connection of Lidstone polynomial and Bernoulli polynomials to obtain new results and connections of Hermite-Bernoulli polynomials and Lidstone polynomials. Some celebrated formulas of Ramanujan are generalized in terms of degenerate Bernoulli polynomials. These results extend some known summations and identities of Ozarslan, Ozden, Dere and Simsek, Bayad et al and Kim et al.

3. Closed form expressions for Dedekind zeta values by Kalyan Chakraborty Harish-Chandra Research Institute, Allahabad kalychak@gmail.com

J. R. Wilton obtained a formula for the product of two Riemann zeta functions. This formula played a crucial role to find the approximate functional equation for the product of two Riemann zeta functions in the critical region. We find an analogous formula for the product of two Dedekind zeta functions and then use this formula to find closed form expressions for Dedekind zeta values attached to arbitrary real as well as imaginary quadratic number fields at any positive integer. This a joint work with Soumyarup Banerjee and Azizul Hoque.

4. Analogue of a Fock-type integral arising from electromagnetism and its applications in number theory by Atul Dixit, IIT Gandhinagar adixit@iitgn.ac.in

Closed-form evaluations of certain integrals of  $J_0(\xi)$ , the Bessel function of the first kind, have been crucial in the studies on the electromagnetic field of alternating current in a circuit with two groundings, as can be seen from the works of Fock and Bursian, Schermann etc. Koshliakov's generalization of one such integral, which contains  $J_s(\xi)$  in the integrand, encompasses several important integrals in the literature including Sonine's integral. Here we derive an analogous integral identity where  $J_s(\xi)$  is replaced by a kernel consisting of a combination of  $J_s(\xi)$ ,  $K_s(\xi)$  and  $Y_s(\xi)$  that is of utmost importance in number theory. Using this identity and the Voronoi summation formula, we derive a general transformation relating infinite series of products of Bessel functions  $I_\lambda(\xi)$  and  $K_\lambda(\xi)$  with those involving the Gaussian hypergeometric function. As applications of this transformation, several important results are derived, including what we believe to be a

corrected version of the first identity found on page 336 of Ramanujan's Lost Notebook.

### 5. On Basic Hypergeometric Series and Continued Fractions by S. Ahmad Ali, Babu Banarasi Das University, Lucknow ali.sahmad@yahoo.com

Ramanujan recorded many continued fractions in his Notebook. In the present talk we give the continued fractions for the ratio of certain basic hypergeometric series. Many continued fractions of Ramanujan and those for some mock theta functions follow as special case of our results.

## Higher Mathematics Education in India

### 1. Higher Mathematics Education in India: Some Challenges by Bhaba Kumar Sharma Indian Institute of Technology Guwahati bks@iitg.ac.in

The Draft New Education Policy (DNEP) envisages to revamp the entire education system in the country, including primary, secondary and higher education. For higher education, its prescriptions include large multidisciplinary higher education institutions across the country, and a more liberal multidisciplinary undergraduate curricula accompanied by rigorous specialization in chosen disciplines or fields. The recommendations of DNEP have been intensely debated by individuals, forums and societies. For example, the three science academies have submitted their analysis and recommendations formulated by taking the opinions of different stakeholders including their members into account. The recommendation of the DNEP for revamping curriculum, pedagogy and assessment, and to move away from solely rote learning of facts and mechanical procedures has been generally welcomed. However, there will be great challenges for this paradigm shift, and will require careful planning and need to place a robust mechanism of huge scale. In this talk, we will discuss some of the challenges of higher education in mathematics in the light of issues that DNEP has brought to the front.

### 2. Teaching Methodology in MTTTS Programme and Pedagogical Benefits of Computer Algebra System in Teaching Mathematics by Ajit Kumar Institute of Chemical Technology, Mumbai ajit72@gmail.com

Mathematics Training and Talent Search (MTTS) Programme is a four-week intensive summer training programme for undergraduate and postgraduate students of mathematics in India which has been organized since 1993. It is one of the most effective and unparalleled training programmes and has made significant impact on mathematical scenario in India. The aim of this presentation is to give a brief introduction of teaching methodology adopted in this programme. We shall also look at how this programme has evolved based on rigorous feedback from participants and resource persons.

The second part of this presentation focuses on pedagogical benefits of using computer algebra systems (CAS) in teaching mathematics. Use of CAS has become a very useful and essential tool in learning, teaching and research in mathematics. Several universities and institutes have made use of such tools as part of their curriculum. We shall look at how these tools can be effectively used in classrooms which can make mathematical content more rich and interesting.

### 3. The importance of problem solving in Mathematics with a special reference to Madhava competition by V.M. Sholapurkar Department of Mathematics, SP College, Pune vmshola@gmail.com

Problem solving is one of the most important aspects of teaching-learning processes in mathematics, especially at the undergraduate level. The present curricula in Indian universities fail to attach weightage to problem solving, as much as it deserves. With a view to address this problem, Department of Mathematics, S. P. College, Pune launched a mathematics competition for undergraduate students in the year 2009-10, named after

14th century Indian mathematician Madhava. After 10 years, the competition has grown into a national level event spread over 23 regions in the country including Delhi, Mumbai, Chennai, Kolkata, Bangaluru, etc. The competition, in some sense, is an extension of the math olympiad competitions for the high school students and invites undergrads to tackle tougher problems in typical undergraduate topics like Calculus, Matrices, Polynomials, Number Theory, etc. The organization of post-competition nurture camps is a distinctive feature of the activity allowing around 100 students to participate in training programmes and interact with experts as well as peers across the country. In this presentation, we propose to talk on the process of cultivating the culture of problem solving with a special reference to Madhava competition.

#### 4. The Role of the National Centre of Mathematics in Higher Mathematics Education in India by Sudhir R. Ghorpade Department of Mathematics Indian Institute of Technology, Bombay Powai, Mumbai 400076, India srg@math.iitb.ac.in

I will give an overview of the activities of the National Centre of Mathematics (NCM), which is a joint centre of IIT Bombay and TIFR. This will include especially the ATM (= Advanced Training in Mathematics) schools, which have been coordinated by the NCM for the past several years, and which appear to be making a positive contribution to higher mathematics education in India.

#### 5. Higher Mathematics Education in India: Radical Changes required in Assessment by S. Kumaresan Department of Mathematics and Statistics, IIT Kanpur kumaresa@gmail.com

Almost all things negative about Education in India can be traced to the wrong notion of equating assessment with written examinations. Though all educationists talk of the evil of rote-learning, what is the root cause of such an approach? In my talk I shall share some of my experiments in assessment and their outcome. I hope to convince the listeners that if one is committed, there are means within the system that pay off.

#### **Report on the Symposium : Higher Mathematics Education in India**

A symposium titled Higher Mathematics Education in India was held on 24 November, 2019 during the 85th Annual Conference of IMS. Initiating the discussion Bhaba Kumar Sarma, IIT Guwahati, placed some systemic issues involved at undergraduate and post-graduate education of Mathematics in the country. It was emphasized that there is a need to place a robust mechanism of huge scale to change the prevailing teaching-learning from rote learning, as envisaged by the new Draft New Education Policy. Prof. S. Kumaresan, IIT Kanpur, emphasized that radical changes are required in assessment and provided several novel new techniques that have been successfully experimented. Dr. Ajit Kumar, ICT Mumbai, presented the teaching methodology in MTTS Programmes, the most successful training programme in Mathematics in the country. V.M. Sholapurkar, S.P. College, Pune, talked about the importance of problem solving and about the experience of Madhava Mathematics Competition, an nationwide competition for undergraduate students in Mathematics. Sudhir R. Ghorpade, IIT Bombay, gave an overview of initiatives and activities (like ATM, AFS, etc.) of National Centre of Mathematics, a joint centre of IIT Bombay and TIFR. There were useful interactions among the speakers and the audience of the symposium.

## Recent Trends in Differential Geometry

1. **Lightlike Submersions** by S.S. Shukla Department of Mathematics, University of Allahabad ssshukla\_au@rediffmail.com

The aim of this talk is to discuss some classes of lightlike submersions from a semi-Riemannian manifold onto a lightlike manifold. We shall also focus on properties of O' Neill's tensors and the geometry of such submersions when the total manifold is equipped with certain structure such as Kaehler or Sasakian.

2. **On Generalized Sasakian-Space-Forms** by D.G. Prakasha Department of Mathematics, Davangere University, Shivangangothri Campus prakashadg@gmail.com

Generalized Sasakian-space-forms have become today a rather special topic in contact Riemannian geometry. The study of Generalized Sasakian-space-forms was initiated by Alegre, Blair and Carriazo. Sasakian space forms and Kenmotsu space forms can be considered as special cases of Generalized Sasakian-space-forms. In this talk, first we explain the main facts about generalized Sasakian-space-forms. Further, some contemporary works are concerned with geometric properties and of their curvature related problems have been discussed. Finally, give the directions to possible extension of this topic.

3. **Geometry of a manifold with first approximate slope metric** by Gau-ree Shanker Department of Mathematics and Statistics, Central University of Punjab grshnkr2007@gmail.com

The geometry on a slope of a mountain is the geometry of a Finsler metric, called the slope metric or Matsumoto metric written as  $F = \frac{\alpha^2}{\alpha - \beta}$ , where  $\alpha = \sqrt{a_{ij}y^i y^j}$  is a Riemannian metric and  $\beta = b_i(x)y^i$  is a 1-form. The metric  $F = \alpha + \beta + \frac{\beta^2}{\alpha}$  is known as first approximate slope metric. In this talk, we discuss about the existence of globally defined first approximate slope metrics on surfaces of revolutions as well as the geodesics's behavior. In the last, we compare Finslerian and Riemannian areas of a bounded region.

4. **Some basic inequalities of curvature like tensors and their applications** by Mukut Mani Tripathi Department of Mathematics, Banaras Hindu University mmtripathi66@yahoo.com

Since the celebrated theory of J. F. Nash of isometric immersion of a Riemannian manifold into a suitable Euclidean space gives very important and effective motivation to view each Riemannian manifold as a submanifold in a Euclidean space, the problem of discovering simple sharp relationships between intrinsic and extrinsic invariants of a Riemannian submanifold becomes one of the most fundamental problems in submanifold theory. The main extrinsic invariant is the squared mean curvature and the main intrinsic invariants include the classical curvature invariants namely the Ricci curvature and the scalar curvature. There are also many other important modern intrinsic invariants of (sub)manifolds introduced by B.-Y. Chen. In this talk, the author will give several inequalities for curvature like tensors. These inequalities will be applied in different kind of Riemannian submanifolds, including submanifolds of real space forms, Kaehlerian slant submanifolds of complex space forms and Legendrian submanifolds of Sasakian space forms. Equality cases will also be discussed.

## Papers for Competition Session

### IMS Prize Group 1

1. Splitting operation for matroids representable over finite fields of prime order by Prashant P. Malavadkar School of Mathematics, MIT World Peace University, Pune - 411038 (India) prashant.malavadkar@mitwpu.edu.in

The notion of splitting operation for binary matroids was introduced by Raghunathan, Shikare and Waphare as a natural generalization of the splitting operation for graphs. The present paper defines related notion of splitting operation for matroids which are representable over  $GF(p)$  and characterizes circuits, bases and hyperplanes of the resulting matroid. It also investigates the effect of this operation on Eulerian, bipartite and connected matroids which are representable over  $GF(p)$ .

### IMS Prize Group 2

1. Pointwise Topologically Stable Actions by Abdul Gaffar Khan Department of Mathematics, University of Delhi, Delhi, India gaffarkhan18@gmail.com

It is well known that the notion of a shadowing property plays a vital role in guaranteeing the topological stability of a dynamical system. Recently, mathematicians started exploring the scope of dynamics of homeomorphisms and continuous flows possessing these notions locally. Motivated from these works, we introduce shadowable points and topologically stable points for finitely generated group actions on compact metric spaces. We studied the relation between the set of all shadowable points with the shadowing of an action and with the set of all shadowable measures. Finally, we proved that every shadowable point of an expansive action is topologically stable.

2. Betti Numbers of Quotients of Rings and Hilbert Polynomials Associated to Derived Functors by Ganesh S. Kadu Department of Mathematics, Savitribai Phule Pune University, Pune, India ganeshkadu@gmail.com

Let  $(A, \mathfrak{m}, k)$  be a Cohen-Macaulay ring of Krull dimension  $d \geq 1$ . Let  $I$  be an  $\mathfrak{m}$ -primary ideal in  $A$ . We consider the following numerical function for  $i \geq 1$ ,

$$n \mapsto l(\mathrm{Tor}_i^A(k, A/I^{n+1})).$$

It is well known that the number  $l(\mathrm{Tor}_i^A(k, A/I^{n+1}))$  is the  $i^{\text{th}}$  Betti number of  $A/I^{n+1}$ . It is also known that this numerical function is given by a polynomial for  $n \gg 0$  of degree at most  $d - 1$ . We show that if  $\mathrm{curv}(I^n) > 1$  for all  $n \geq 1$  then the degree of the polynomial is exactly  $d - 1$ . We also note that there are lots of examples of ideals satisfying the condition  $\mathrm{curv}(I^n) > 1$  for all  $n \geq 1$ . We also consider more general functions for maximal Cohen-Macaulay  $A$ -module  $M$ ,

$$n \mapsto l(\mathrm{Tor}_i^A(M, A/I^n))$$

We prove that this function is given by a polynomial of degree  $d - 1$  when the reduction number of ideal  $I$  is one.

### IMS Prize Group 4

1. The incomplete exponential  ${}_pR_q(\alpha, \beta; z)$  function with an application by Ankit Pal Department of Applied Mathematics and Humanities, Sardar Vallabhbhai National Institute of Technology, Surat-395 007, Gujarat, India ankit.pal07@gmail.com



An attempt is made to define the incomplete exponential  ${}_pR_q(\alpha, \beta; z)$  function and its properties. Further we establish generating function for the given function. An application have also been discussed related to the area of ground water pumping modelling.

## IMS Prize Group 5

1. A study of analytical solution on imbibition phenomenon in a fractured porous medium by Juhi Kesarwani Department of Applied Mathematics & Humanities

S. V. National Institute of Technology Surat naincyas@gmail.com

The counter-current imbibition phenomenon is studied in a fractured porous medium and explore the effects of viscosity ratio, inclination angle and gravitational force on the field of oil production. Relative permeability and Capillary pressure has been analyzed on the saturation profile of the wetting phase by deriving a mathematical expression for the wetting phase saturation profile during imbibition process and discussed the behavior of all parameters on the saturation and recovery rate of the fractured reservoir.

2. The effect of imperfect interface on SH wave propagation in micropolar layer/half-space configuration by Mriganka Shekhar Chaki Department of Applied Mathematics, Indian Institute of Technology (ISM) Dhanbad mriganka.chaki@gmail.com

The present study articulates SH wave propagation in a layer/half-space configuration consisting of micropolar layer imperfectly bonded to a micropolar half-space. Closed-form expressions of dispersion equations for Love-type wave and new-type dispersive wave due to microrotations have been obtained. The obtained analytical results have been validated with the classical cases in literature. The influence of transverse force stiffness, normal couple stiffness and transverse couple stiffness coefficients associated with imperfect interface on Love-type wave and new-type dispersive wave has been studied through graphical illustrations.

3. Mathematical Modelling of surface wave transference through imperfect interface between two dissimilar Functionally Graded Piezoelectric Materials by Sonali Mondal Department of Mathematics and Computing, IIT(ISM) Dhanbad, 826004, Jharkhand sonalimondal.am@gmail.com

In the present paper, a theoretical investigation has been carried out to analyse the propagation of shear horizontal surfacewaves (SH-waves) in a structure consisting of an FGPM layer lying over an FGPM half-space. The material properties of FGPM layer are assumed to have exponential function distribution along the thickness direction whereas those of FGPM half-space are presumed to have quadratic variation. The interface between the FGPM layer and the FGPM half-space has been considered to be imperfect. At the surface, two cases are considered, electrically open case and electrically short case. Moreover two types of imperfections at the interface are taken into account (one as mechanically compliant and dielectrically weakly conducting and other as mechanically compliant and dielectrically highly conducting). Variableseparable method is used for the wave solution. In particular, the solutions for mechanical displacement and electricpotential function for FGPM half-space has been obtained in the form of modified Bessel function. The dispersion relation for each case is obtained in determinant form using suitable boundary conditions. Numerical example is given and graphs are plotted. The numerical results show that the surface wave velocity is affected by the gradient coefficient of the two FGPM media and the degree of mechanically and dielectrically imperfection at the interface between the covering layer and the substrate. This study finds its application in optimization of SAW devices.

## IMS Prize Group 6

1. **Mathematical Modeling of Malaria with Saturated Treatment and Optimal Control-A Case Study of India** by Akhil Kumar Srivastav Division of Mathematics, School of Advanced Sciences Vellore Institute of Technology, Chennai, India akhilkumar.srivastav@vit.ac.in

Malaria is a life-threatening mosquito-borne disease. It is transmitted through the bite of an infected Anopheles mosquito. People who get infected with malaria become very sick with high fevers, chills, and flu-like symptoms. Malaria may be fatal if not treated promptly. Here we propose an SIS model to study the transmission dynamics of malaria with saturated treatment. We assume that the mosquito population is growing logistically in the environment. Here we include a saturated type treatment function which is more suitable for the regions with limited resources. We discuss the existence and stability of different equilibria of the proposed model. We also compute the basic reproduction number  $R_0$  which plays an important role in existence and stability of equilibria of the model. We estimate the parameter corresponding to transmission of malaria using real data from different states of India by least square method. We also perform sensitivity analysis to identify the key parameters which influence the basic reproduction number and hence regulate the transmission dynamics of malaria. Numerical simulations are presented to illustrate the analytic findings. Finally, we extend our model to optimal control problem to find the suitable cost-effective and time-dependent control strategies to reduce the number of infectives in a desired interval of time.

2. **Generation of Random numbers using LCG and Low discrepancy sequence** by Mahesh Sudhakar Naik Department of Basic Sciences & Humanities SVKM's NMIMS Mukesh Patel School of Technology Management & Engineering, Mumbai, India Mahesh.naik@nmims.edu

Many statistical and mathematical models depend on random data for further analysis. These random data are dependent on the random sequences produced with the help of generators. Random numbers are significantly used in Numerical Analysis, Simulation, Monte Carlo methods, Cryptography and many such fields. In this paper an attempt has been made to design a generator using the existing generator and quasi random sequences, as both these methods have their own advantages and disadvantages, here the focus is to combine the advantages and reduce the weakness thus putting forward a new approach to produce random numbers.

## A M U Prize

1. **Characterization of prime near rings with multiplicative generalized derivations** by Inzamam ul Huque Department of Mathematics Aligarh Muslim University, Aligarh, India inzamamulhuque057@gmail.com

In this paper, we investigate multiplicative generalized derivations and multiplicative multipliers satisfying certain differential identities on semigroup ideals of a left near ring and discuss related results. Moreover, we provide examples to show that the assumed restrictions cannot be relaxed.

2. **FI-Semi injective modules** by Manoj Kumar Patel Department of Mathematics National Institute of Technology Nagaland, Dimapur - 797103, Nagaland, India mkpibt@gmail.com

This paper introduce and investigate the notion of  $FI - M$ -principally injective and  $FI$ -semi-injective (fully invariant-semi injective) modules. Clearly  $FI$ -semi-injective module does not satisfies the  $(C_1)$  condition, so we provide several sufficient conditions under which  $FI$ -semi-injective modules to be continuous. Apart from this we obtain more

results related with uniform, weakly co-Hopfian and square free modules and shows that it satisfies the SSP and SIP property. Also investigate the characterizations of PP-ring and commutative semi-simple rings in term of  $FI$ -semi-injective modules. Finally shows that the property of being  $fi$ -semi-injective is Morita invariant.

3. **Backward-forward dynamical systems with preconditioning for monotone inclusion problem** by Pankaj Gautam Department of Mathematical Sciences Indian Institute of Technology (BHU), Varanasi, India [pankajg.rs.mat16@iitbhu.ac.in](mailto:pankajg.rs.mat16@iitbhu.ac.in)

In this work first-order backward-forward dynamical systems with preconditioning associated with monotone inclusion in real Hilbert space have been investigated. The operators are chosen in such a way that it is closely related to the forward-backward dynamical system with preconditioning and has the same computational complexity. Existence, uniqueness, and convergence of the generated trajectories of the dynamical system have been studied. I also establish that an equilibrium point of the trajectory is globally exponentially stable and monotone attractor. As a particular case, I explore similar perspectives of the trajectories generated by a dynamical system related to the minimization of the sum of a nonsmooth convex and a smooth convex function. Numerical examples are cited to illustrate the convergence of trajectories.

## V M Shah Prize

1. **Nonexistence of conjugacy via kneading matrix** by Chaitanya G K Department of Mathematical and Computational Sciences National Institute of Technology Karnataka Suarthal, Mangalore- 575 025 [cberbalaje@gmail.com](mailto:cberbalaje@gmail.com)

Continuous piecewise monotone self-maps of a compact interval in the real line provide interesting examples of discrete dynamical systems, however their behaviour can be very complicated. Milnor and Thurston, in their kneading theory to study the iterates of such maps, have proved that the kneading matrix associated with a piecewise monotone map is invariant under orientation-preserving topological conjugacy. In this paper, by exhibiting an interesting relation between kneading matrices, we prove that the kneading matrix is not invariant under orientation-reversing topological conjugacy. Further, as an application, we illustrate how our result can be used to prove the nonexistence of topological conjugacy between such maps.

2. **Coefficient Multipliers on class of vector valued multiple Dirichlet Series having complex frequencies** by Nibha Dua Department Of Mathematics, Netaji Subhas Institute Of Technology University of Delhi, Sector 3 Dwarka, New Delhi-110078 , India [nibhad.phd.16@nsit.net.in](mailto:nibhad.phd.16@nsit.net.in)

In the present paper we deal with vector valued Dirichlet series in ‘n’ complex variables and having complex sequence of exponents. We obtain the necessary and sufficient condition on vector valued coefficients for the series to converge absolutely in the entire complex plane. Later we study the coefficient multipliers for a class of such series defining an entire function in  $\mathbb{C}^n$ .

## Contributory Papers

### Section A : Combinatorics, Graph Theory and Discrete Mathematics

1. **Flow-up bases and Basis criteria for Generalized Spline Modules on Dutch Windmill graph** by Radha Madhavi Duggaraju Navrachana University,

Vadodara, India 15721006@nuv.ac.in

Let  $G$  be an edge labeled graph whose edges are labeled by ideals of a ring  $R$  where  $R$  is a commutative ring with identity. A generalized spline is a vertex labeling over an edge labeled graph  $G$ , such that the difference of vertex labels of adjacent vertices belongs to the edge ideal associated to the edge joining those vertices. The set of generalized splines has a ring as well as  $R$ -module structure. We find flow-up bases for generalized spline modules on edge labeled Dutch Windmill graph also known as Friendship graph, consisting of  $m$  copies of triangles sharing a common vertex. We use the method based on the zero trials of the edge labeled graph  $G$ . We also generalize the method to find flow-up bases for generalized spline modules on edge labeled Dutch Windmill graph consisting of  $m$  copies of  $n$ -cycles (for any positive integer  $n$ ) sharing a common vertex. We take the base ring  $R$  to be the greatest common divisor domain. Also, we give basis criteria for generalized splines on Dutch Windmill graph by using determinantal techniques.

2. Degree Based Topological Indices of  $C_8$  Layer Structure by Syeda Afiya, PG Department of Mathematics Women's Christian College, Chennai 600006. afiyazakia@gmail.com

Chemical Graph Theory is the topology branch which combines graph theory to math modelling using chemical phenomena. Chemical reaction network theory is an area of applied mathematics that attempts to model the behavior of real world. A network is simply a connected graph having no multiple edges and loops. A chemical graph is a graph whose vertices denote atoms and edges denote bonds between those atoms of any underlying chemical structure. The degree of a vertex is the number of vertices which are connected to that fixed vertex by the edges. The pioneers of the chemical graph theory are Haruo Hasaya, Ivan Gutman, Milan Randic and N.Trinajstic and Harry Weiner. It has aroused interest from pure mathematicians due to its interesting problems that arise from the mathematical structures involved. In this report, we compute newly defined topological indices, namely, arithmetic-geometric index, SK index, index, modified Randic index and sum-connectivity of Layer.

3. A Note on the  $r$ -Locating-Domination and  $r$ -Locating-Total Domination in Graphs by R. Jayagopal, School of Advanced Sciences Vellore Institute of Technology, Chennai-600 127, India jgopal89@gmail.com

A set  $S$  of vertices in a graph  $G$  is called a distance  $r$ -dominating set and a distance  $r$ -total dominating set of  $G$  if every vertex in  $V(G)\setminus S$  and  $V(G)$  such that  $d(v, x) \leq r, v \in S$  respectively. The minimum cardinality of a distance  $r$ -dominating set and a distance  $r$ -total dominating set of  $G$  is called the distance  $r$ -domination number  $\gamma_r(G)$  and the distance  $r$ -total domination number  $\gamma_{t,r}(G)$  respectively. A  $r$ -locating-dominating set in a connected graph  $G$  is a  $r$ -dominating set  $S$  of  $G$  such that for every pair of vertices  $u$  and  $v$  in  $V(G)\setminus S$ ,  $N(u) \cap S \neq N(v) \cap S$ . Moreover if  $S$  is a  $r$ -total dominating set  $S$  of  $G$  then  $S$  is called as  $r$ -locating-total dominating set of  $G$ . The minimum cardinality of a  $r$ -locating-dominating set and  $r$ -locating-total dominating set of  $G$  is denoted as  $\gamma_r^L(G)$  and  $\gamma_{r,t}^L(G)$  respectively. The problems' motivation comes from the study of the location of monitoring devices to safeguard a system, in which the process involves the following two steps, one is sensing a fault among its neighbors and the other is locating the faulty sites. In this paper we obtain a lower bound for the  $r$ -locating-total dominating set and also find the graphs which attain this lower bound. Moreover, graphs like necklace graphs, windmill graphs and coronagraphs have also been discussed.

4. On removal of perfect matching from folded hypercubes by S.A. Mane, Department of Mathematics, S. P. Pune University, Pune, India manesmruti@yahoo.com

The hypercube  $Q_n$  of dimension  $n$  is one of the most versatile and powerful interconnection networks. The  $n$ -dimensional folded cube denoted as  $FQ_n$ , a variation of the hypercube

possesses some embeddable properties that the hypercube does not possess. Dong and Wang (In Theor. Comput. Sci.771(2019)93 – 98) conjectured that "A subset  $E^m$  of  $2^n - 1$  edges of  $FQ_n$  is a perfect matching if and only if  $FQ_n - E^m$  is isomorphic to  $Q_n$ ". In this paper, we disprove this conjecture by providing some perfect matchings removal of which from  $FQ_n$  do not give a graph isomorphic to  $Q_n$ .

5. Generalized 3-connectivity and Pendant 3-tree-connectivity of Augmented Cubes by Smita Kandekar, Department of Mathematics, S. P. Pune University, Pune, India, smitakandekar54@gmail.com

In a connected graph  $G$ , for a given set  $S \subseteq V(G)$  with at least two vertices, an  $S$ -Steiner tree is a subgraph  $T$  of  $G$  such that it is a tree with  $S \subseteq V(T)$ . For a given set  $S \subseteq V(G)$  and  $|S| \geq 2$ , the generalized local connectivity, denoted by  $\kappa_G(S)$ , is the maximum number of internally disjoint  $S$ -Steiner trees in  $G$ . For an integer  $k$  with  $2 \leq k \leq |V(G)|$ , the generalized  $k$ -connectivity (or  $k$ -tree-connectivity) is defined as

$$\kappa_k(G) = \min\{\kappa_G(S) : S \subseteq V(G), |S| = k\}.$$

For an  $S$ -Steiner tree, if the degree of each vertex in  $S$  is equal to one, then that tree is called a pendant  $S$ -Steiner tree. For  $S \subseteq V(G)$  and  $|S| \geq 2$ , the local pendant tree-connectivity  $\tau_G(S)$  is the maximum number of internally disjoint pendant  $S$ -Steiner trees in  $G$ . For an integer  $k$  with  $2 \leq k \leq |V(G)|$ , the pendant  $k$ -tree-connectivity is defined as

$$\tau_k(G) = \min\{\tau_G(S) : S \subseteq V(G), |S| = k\}.$$

The hypercube  $Q_n$ , is very popular interconnection network. Augmented cube  $AQ_n$ , is one of the important variations of hypercube due to its favorable properties, useful in routing algorithms and in fault tolerant systems. In this paper, we have shown that for  $n \geq 3$ , the generalized 3-connectivity of  $AQ_n$ ,  $\kappa_3(AQ_n) = 2n - 2$  and the pendant 3-tree-connectivity of  $AQ_n$ ,  $\tau_3(AQ_n) = 2n - 3$ .

6. Trace description and Hamming weights of irreducible constacyclic codes by Saroj Rani Department of Mathematics S.A. Jain P.G. College, Ambala City 134003, India iitsaroj@gmail.com

Irreducible constacyclic codes constitute an important family of error-correcting codes and have applications in space communications. Their error-performance relative to various communication channels is measured by their weight distributions, which have been an interesting object of study for a long time. We provide a trace description of irreducible constacyclic codes of length  $n$  over the finite field  $\mathbb{F}_q$  of order  $q$ , where  $n$  is a positive integer and  $q$  is a prime power coprime to  $n$ . As an application, we determine Hamming weight distributions of some irreducible constacyclic codes of length  $n$  over  $\mathbb{F}_q$ . In this talk, I would like to discuss all these results. This is joint work with Prof. Anuradha Sharma.

7. Arithmetic properties for  $k$ -tuples  $t$ -core partitions by Ranjit Mehatari<sup>1</sup>, M. Rajesh Kannan<sup>2</sup>, Aniruddha Samanta<sup>2</sup> <sup>1</sup>Department of Mathematics, National Institute of Technology Rourkela, India <sup>2</sup> Department of Mathematics, Indian Institute of Technology Kharagpur, India aniruddha.sam@gmail.com

A complex unit gain graph is a simple graph in which each orientation of an edge is given a complex number with modulus 1 and its inverse is assigned to the opposite orientation of the edge. In this article, first we establish bounds for the eigenvalues of the complex unit gain graphs. Then we study some of the properties of the adjacency matrix of complex unit gain graph in connection with the characteristic and the permanental polynomials. Then we establish spectral properties of the adjacency matrices of complex unit gain graphs. In particular, using Perron-Frobenius theory, we establish a characterization for bipartite graphs in terms of the spectrum of complex unit gain graph and the spectrum of the underlying graph. Also, we derive an equivalent condition on the gain so that the eigenvalues of the gain graph and the eigenvalues of the underlying graph are the same.

## Section B : Algebra, Number Theory and Lattice Theory

1. Strong Regularity & Related Concepts by Shankar Rajak Dept. Of Mathematics, B.N. Mandal University, Madhepura-852113, maakalashoolmath@gmail.com

In this paper we have generalized some properties of strongly reduced near-rings. We have characterized some results on strong regularity in near-rings which are closely related with strongly reduced near-rings. A near ring is said to be left regular if for each  $a \in R$ , there exists  $x \in R$  such that  $a = xa^2$ . A near-ring is called strongly left regular if  $R$  is left regular and regular, similarly we define right regular. A strongly left and strongly right regular near-ring is called strongly regular near-ring. We find that the concept of left, strongly left, strongly right and strong regularities are all equivalent. A near-ring  $R$  is reduced if  $R$  has no non-zero nilpotent elements. That is, for each  $a$  in  $R$ ,  $a^n = 0$  for some positive integer  $n$  implies  $a = 0$ . A near-ring is strongly reduced, if for each  $a \in R$ ,  $2 \in R_c$  that is  $a0 = a^2$  implies  $a0 = a$ . We find that a strongly regular near-ring is reduced and every strongly reduced near-ring is reduced.

2. On  $L$ -fuzzy automata with  $L$ -fuzzy partitions by Shailendra Singh Department of Mathematics & Computing Indian Institute of Technology (ISM) Dhanbad, India shailendrasingh281293@gmail.com

This paper is towards the study of theory of fuzzy automata with fuzzy partitions based on complete residuated lattices. Specifically, we study the concept of the  $L$ -fuzzy partitioned automaton corresponding to a given  $L$ -fuzzy automaton, whose set of states is a space with an  $L$ -fuzzy partition of the set of states of such given automaton. Also, we introduce the relationship among the  $L$ -fuzzy languages of the  $L$ -fuzzy partitioned automaton and  $L$ -fuzzy automaton. Further, we introduce the concept of a crisp-deterministic  $L$ -fuzzy automaton corresponding to the  $L$ -fuzzy partitioned automaton such that both accept the same  $L$ -fuzzy language. Finally, the notion of the fuzzified  $L$ -fuzzy partitioned automaton corresponding to a given  $L$ -fuzzy partitioned automaton is introduced and a characterization of its  $L$ -fuzzy language is given.

3. On Deterministic Fuzzy Automata and languages in category theoretic setting by Priyanka Pal, Department of Mathematics & Computing Indian Institute of Technology (ISM) Dhanbad, India priyankapal2192@gmail.com

The purpose of the given work is to introduce the categories of deterministic fuzzy automata and fuzzy languages based on a complete residuated lattice without zero divisors. Specifically, we associate two deterministic fuzzy automata with a given deterministic fuzzy automaton and show that the reachability and observability maps of the given deterministic fuzzy automaton turn out to be morphisms in the category of deterministic fuzzy automata. Finally, the observability map of one of the associated deterministic fuzzy automaton led to deduce the well-known relationship between a fuzzy regular language and Myhill-Nerode equivalence.

4. Invariants of the symbolic powers of edge ideals by Bidwan Chakraborty, Department of Mathematics Indian Institute of Technology Kharagpur, India bidwanc@gmail.com

Let  $G$  be a graph and  $I = I(G)$  be its edge ideal. When  $G$  is the clique sum of two different length odd cycles joined at single vertex then we give an explicit description of the symbolic powers of  $I$  and compute the Waldschmidt constant. When  $G$  is complete graph then we describe the generators of the symbolic powers of  $I$  and compute the Waldschmidt constant and the resurgence of  $I$ . Moreover for complete graph we prove that the Castelnuovo-Mumford regularity of the symbolic powers and ordinary powers of the edge ideal coincide.

5. On the relationship between fuzzy reflexive approximation spaces and fuzzy transformation systems by Sutapa Mahato, Department of Mathematics and Computing, Indian Institute of Technology (ISM), Dhanbad-826004, India sutapaiitdhanbad@gmail.com

The objective of this paper is to establish the relationship between fuzzy reflexive approximation operators and fuzzy transformation systems. We show that for each upper fuzzy transformation system there exists a fuzzy reflexive approximation space and vice-versa. We further establish such relationship between lower fuzzy transformation systems and fuzzy reflexive approximation spaces under the condition that the undersign lattice structure satisfies double negation law.

6. Invariants of edge ideal of some class of weighted oriented graphs by Dipak Kumar Pradhan, Department of Mathematics, Indian Institute of Technology Kharagpur, India, saidipakkumar94@gmail.com

Let  $D$  be a weighted oriented graph and let  $I(D)$  be its edge ideal. We give explicit formula for the projective dimension and regularity of edge ideal of weighted oriented dumbbell graph, complete graph and join of an arbitrary graph and a cycle.

7. Some new results on Commutative Algebra by Abhik Singh, Department of Mathematics, Patna University Patna-800005, Bihar, India abhik51@gmail.com

In this paper, we shall discuss and give applications of a polarization formula, which yields estimates of  $x_1 \dots x_n$  when estimates of  $x^n$  are given, and estimates of the polarized forms of the terms of the Taylor expansion of a bounded holomorphic function over a ball in Banach space. The polarization formula can be used to obtain new properties of commutative algebras, with a convex topology or a convex bounded structure. The polarization formula will be proved and then few applications will be given in which we obtain estimates of  $x_1 \dots x^n$  from estimates of  $x^n$ . We shall also define the infinite dimensional holomorphic functional calculus.

8. On Relational Aspects of  $L^M$ -valued  $F$ -transforms by Abha Tripathi, Department of Mathematics and Computing Indian Institute of Technology, India tripathiabha29@gmail.com

The purpose of the present work is to introduce and study the concept of the many-valued version of  $L$ -valued  $F$ -transforms (in short,  $L^M$ -valued  $F$ -transforms). Further, we established the relationship between  $L^M$ -valued fuzzy rough sets and  $L^M$ -valued  $F$ -transforms and shown that  $L^M$ -valued  $F$ -transforms are particular cases of  $L^M$ -valued fuzzy rough approximation operators. Finally, by defining the notion of  $L^M$ -valued fuzzy transformation systems, we developed the relationship with  $L^M$ -valued  $F$ -transforms.

9. Four Equalities Connected with Intuitionistic Fuzzy Matrices by J. Boobalan, Department of Mathematics, Annamalai University Annamalai Nagar - 608 002, India jboobalan@hotmail.com

In the present work, we prove four new equalities connected with intuitionistic fuzzy matrices under the basic operations:  $+$ ,  $\cdot$ ,  $\odot$ ,  $\otimes$ ,  $\cup$ ,  $\cap$ .

10. Primality Test with Lucas Sequences by B. Ravitheja, Department of Mathematics, Andhra University Visakhapatnam, Andhra Pradesh, India baduguraviteja@gmail.com

Study on Primality tests is an important study in Number Theory. There are several known tests for primality. In this paper we give a primality test for positive integer  $N > 1$  by adapting a group structure on the set  $\{(V_m(a, 1), U_m(a, 1))\}_{m \in \mathbb{Z} \cup \{0\}}$  of all

Lucas sequences of order  $S(N)$  where  $S(N)$  is an analogue of  $\phi(N)$  given as  $S(N) = \text{lcm}[all p_i^{\alpha_i-1}(p_i - (\frac{\Delta}{p_i}))]$  where  $\Delta = a^2 - 4$  for some integer  $a$ .

11. Counting in Residue of a Polynomial ring  $\mathbf{Z}_n[\mathbf{x}]$  by P. Anuradha Kameswari, Department of Mathematics, Andhra University Visakhapatnam, Andhra Pradesh, India panuradhakameswari@yahoo.in

In the context of cryptosystems over polynomial residue ring, counting in  $\mathbf{Z}_n[\mathbf{x}]$  plays an important role. In this paper for any primitive polynomial  $f(x)$  in  $\mathbf{Z}_n[\mathbf{x}]$ , we propose formulas, for counting the number of  $g(x) \in \mathbf{Z}_n[\mathbf{x}]$  with  $\text{deg}(g(x)) \leq \text{deg}(f(x))$  that are co prime to  $f(x)$  and counting the number of factors of  $f(x)$ . These formulas are developed by introducing analogues to arithmetical functions  $\mu, \phi$  and  $\sigma$  in  $\mathbf{Z}_n[\mathbf{x}]$ .

12.  $\mathfrak{p}$ -invariant for Elementary Type Fields by Leena Jindal, Centre for Advanced Study in Mathematics Panjab University, Chandigarh, India leenajindal@gmail.com

Let  $F$  be a field of characteristic  $\neq 2$ . we have defined a new rational valued numerical invariant of the field  $F$  with  $|F^\times/F^{\times 2}| < \infty$ , that we call  $\mathfrak{p}$ -invariant and computed it for some well-known fields. In some sense,  $\mathfrak{p}(F)$  gives the probability of a randomly chosen quaternion algebra being division.  $\mathfrak{p}$ -invariant of iterated Laurent series field  $F((t_1))((t_2)) \dots ((t_n))$  is calculated by knowing  $\mathfrak{p}(F)$  and  $|F^\times/F^{\times 2}|$ . Splitting probability of  $F$  (i.e.,  $1 - \mathfrak{p}(F)$ ) is multiplicative over the fibre product of fields. We have also proved that  $\mathfrak{p}$ -invariant of two fields is same if they are Witt equivalent. With the help of these results, we count the number of distinct  $\mathfrak{p}$ -invariants of elementary type fields for a given number of square classes  $|F^\times/F^{\times 2}|$ .

13. Arithmetic properties for  $k$ -tuples  $t$ -core partitions by Ranganatha Dasappa, Department of Mathematics, Central University of Karnataka Kalaburagi-570006, Karnataka, India ddranganatha@gmail.com

Let  $A_{t,k}(n)$  denote the number of  $k$ -tuple partitions of  $n$  where each partition is  $t$ -core. In this paper, we generalize some results due to Saikia and Boruah on congruence properties for  $A_{3,9}(n)$ ,  $A_{9,3}(n)$  and  $A_{4,8}(n)$ .

14. A finite field analogue of the Appell series  $F_4$  by Mohit Tripathi, Department of Mathematics, Indian Institute of Technology Guwahati North Guwahati, Guwahati-781039, Assam, INDIA m.tripathi@iitg.ac.in

We define a function as a finite field analogue of the classical Appell series  $F_4$  using Gauss sums. We establish identities for  $F_4^*$  analogous to those satisfied by the classical Appell series  $F_4$ .

15. On  $b$ -generalized derivations in rings with involution by Muzibur Rahman Mozumder, Department of Mathematics, Aligarh Muslim University muzibamu81@gmail.com

Throughout  $R$  will represent an associative ring with centre  $Z(R)$ . An additive map  $x \mapsto x^*$  of  $R$  into itself is said to be an involution if (i)  $(xy)^* = y^*x^*$  and (ii)  $(x^*)^* = x$  holds for all  $x, y \in R$ . A ring  $R$  together with an involution is known as ring with involution or  $*$ -ring. An element  $x$  in a ring with involution is said to be hermitian if  $x = x^*$  and skew-hermitian if  $-x = x^*$ . The purpose of this paper is to investigate the special type of mappings defined on  $R$ . In fact it is shown that these mappings are actually the  $b$ -generalized derivation defined on  $R$ .

## Section C : Real and Complex Analysis



1. Fractional calculus of the product of Generalized M-series of power function, Bessel functions and I-function of one variable by <sup>1</sup>Dheerendra Shanker Sachan, <sup>2</sup>Harsha Jalori, <sup>3</sup>Shailesh Jaloree <sup>1</sup>Department of Mathematics St.Marys P. G. College, Vidisha (M.P.) <sup>2</sup>Department of Physics Govt Dr. Shayama Prasad Mukharjee Science & Commerce College, Bhopal <sup>3</sup>Department of Mathematics Samrat Ashok Technological Institute, Vidisha shailesh\_jaloree@rediffmail.com

In the present paper we have established the Riemann-Liouville fractional integral and derivative of the product of the generalized M-series of power function, Bessel function of first kind and I-function of one variable .The M-series is a particular case of the  $\bar{H}$  function of Inayat Husain. Our results are general and unified in nature. Bessel function of first kind has diverse application in physics and engineering, in connection with fluid motion, elasticity, and propagation of waves diffusion involving cylindrical symmetry and in problems of potential theory.A number of known and new results can be obtained by suitably specializing the parameters involved in the generalized M-series and I-function of one variable.

2. On the value distribution of a Differential Monomial and some normality criteria by Bikash Chakraborty, Department of Mathematics Ramakrishna Mission Vivekananda Centenary College, West Bengal, India bikash@rkmvccrahara.org

Let  $f$  be a transcendental meromorphic function defined in the complex plane  $\mathbb{C}$ , and  $\varphi(\neq 0, \infty)$  be a small function of  $f$ . In this paper, We give a quantitative estimation of the characteristic function  $T(r, f)$  in terms of  $N\left(r, \frac{1}{M[f]-\varphi(z)}\right)$  as well as  $\bar{N}\left(r, \frac{1}{M[f]-\varphi(z)}\right)$ , where  $M[f]$  is the differential monomial, generated by  $f$ .

Moreover, we prove one normality criterion: Let  $\mathcal{F}$  be a family of analytic functions on a domain  $D$  and let  $k(\geq 1)$ ,  $q_0(\geq 3)$ ,  $q_i(\geq 0)$  ( $i = 1, 2, \dots, k-1$ ),  $q_k(\geq 1)$  be positive integers. If for each  $f \in \mathcal{F}$ ,  $f$  has only zeros of multiplicity at least  $k$ , and  $f^{q_0}(f')^{q_1} \dots (f^{(k)})^{q_k} \neq 1$ , then  $\mathcal{F}$  is normal on domain  $D$ .

3. Laplace transform in Bicomplex space and applications by Ritu Agarwal, Department of Mathematics Malaviya National Institute of Technology, Jaipur, India ragarwal.maths@mnit.ac.in

Bicomplex analysis is the most recent mathematical tool applied in Physics, Electric circuit theory, Power system load frequency control, Control engineering, Communication, Signal analysis and design, System analysis and solving differential equations. In this paper we prove the inversion formula for bicomplex Laplace transform, some of it's properties and convolution theorem for complexified Laplace transform to bicomplex variables that is capable of transferring signals from real-valued ( $t$ ) domain to bicomplex frequency ( $\xi$ ) domain. The bicomplex inverse Laplace transform of a convolution function has been illustrated with the help of an example. Physical Applications of bicomplex Laplace transform in finding solution of bicomplex Maxwell's equation and bicomplex Schrödinger equation for free particle are given.

4. On  $\phi$ - Statistically Convergence by Shyamal Debnath, Department of Mathematics, Tripura University, Agartala, India shyamalnitamath@gmail.com

Statistical convergence was introduced in connection with problems of series summation. The main idea of the statistical convergence of a sequence  $x_n$  is that the "majority" of elements from the sequence converge, and we do not care what is going on with other elements. In this paper, by using the Orlicz function, we introduce a concept of  $\phi$ -statistically convergence, as a generalization of the convergence as well as  $\phi$ - convergence. Also, we observe some basic properties and some topological properties of the  $\phi$ -statistically convergence.

5. On the Bohr radius problem by Nilanjan Das, Department of Mathematics Indian Institute of Technology Kharagpur, India nilanjand7@gmail.com

In this talk we will explore various aspects of the Bohr radius problem, and discuss the extensions of Bohr inequality in different directions. We will also present some of our works regarding the Bohr phenomenon for holomorphic and harmonic functions.

6.  $(p, q)$ -Mellin Transform and Applications by P. Jain, C. Basu, V. Panwar Department of Mathematics, South Asian University New Delhi, India vivek.pan1992@gmail.com

Integral transforms play an important part in solving many differential and integral equations. Historically, in 1876, Riemann, first recognized the Mellin transform. In 1894, Mellin gave an elaborate discussion of the Mellin transform and its inversion formula. Later, in 2006, Fitouhi et.al. introduced the concept of  $q$ -Mellin transform in the framework of quantum calculus and studied its applications in solving some integral equations. In this paper, we have introduced and studied  $(p, q)$ -Mellin transform, its convolution and inversion. Some applications of  $(p, q)$ -Mellin transform in solving integral equations are also given.

7. Properties of Cauchy wavelet transform in tube domains by V.R. Lakshmi Gorty, Department of Basic Science of Humanities, SVKM's NMIMS University, Vile Parle (W), Mumbai, 400056. India. vr.lakshmigorty@nmims.edu

Relations of Cauchy wavelet transforms in tube domains between Hilbert transforms, Weyl integrals and their generalizations are obtained. These relations are used to derive new inversion, Parseval formula, boundedness and approximation results for the wavelet transform on  $L^p$ -spaces.

8. Geometric Properties of the Extended Confluent  $\tau$ - Hypergeometric Function by R. Roy, R. K. Jana Department of Applied Mathematics & Humanities S. V. National Institute of Technology Surat - 395007, India. 2011rroy@gmail.com

In this present investigation, we have considered the normalized form of the Extended Confluent  $\tau$ - Hypergeometric Function. We obtained several conditions so that the Extended Confluent  $\tau$ - Hypergeometric Function has some geometric properties including univalence, starlikeness and convexity in the unit disk  $|z| < 1$ .

9. Weighted densities using modulus functions and corresponding ideals by Kumardipta Bose, Department of Mathematics, Jadavpur University, India kumardipto@gmail.com

In this paper we extend the idea of weighted density of [BDFS] by using a modulus function and introduce the idea  $f$ -density of weight  $g$  of subsets of  $\omega := \{0, 1, \dots\}$  (at the same time extending the notion of  $f$ -density [ALR]), which we name  $d_g^f$  where  $g: \omega \rightarrow [0, \infty)$  satisfies  $g(n) \rightarrow \infty$  and  $n/g(n) \rightarrow 0$  and  $f$  is a modulus function. The aim of this paper is to show that we can get new ideals  $\mathcal{Z}_g(f)$  consisting of sets  $A \subset \omega$  for which  $d_g^f(A) = 0$  different from all the previously constructed ideals  $\mathcal{Z}_g$  of [BDFS] and moreover they retain all the nice properties of the ideals  $\mathcal{Z}_g$ .

10. A Note on Different Types of Ideal Convergence of Sequences of Real-valued Functions by Sayan Sengupta, Department of Mathematics, Jadavpur University, India sengupta.sayan20@gmail.com

In this work we consider the notions of different types of  $\mathcal{I}^{\mathcal{K}}$ -convergence of sequences of real-valued functions and obtain certain combinatorial characterizations of ideals for

which specific implications between these types of convergence hold.

11. On Weighted Bilinear Inequalities with Variable Limits of Integrals by Saikat Kanjilal, Department of Mathematics Faculty of Mathematics and Computer Science South Asian University, Chanakyapuri, New Delhi- 110021, India saikat.kanjilal.07@gmail.com, saikatkanjilal@students.sau.ac.in

The weight characterization of the weighted bilinear Hardy inequality has been obtained by Cañestro *et al.* (2012) and Křepela (2017). The aim in this presentation is to provide the weight characterizations of the weighted bilinear Hardy inequality in which the integrals have variable limits for possible choices of indices.

12. Growth properties of solutions of complex linear differential-difference equations with coefficients having the same  $\phi$ -order by Sanjib Kumar Datta, Nityagopal Biswas Department of Mathematics, University of Kalyani Kalyani, Nadia, West Bengal - 741235, India. nityamaths@gmail.com

In this paper, we study the growth properties of solutions of complex linear differential-difference equations with entire or meromorphic coefficients of finite  $\phi$ -order,  $\phi$  being a non-decreasing unbounded function. Here we obtain some results extending earlier theorems due to Wu-Zheng [S. Z. Wu and X. M. Zheng, Growth of meromorphic solutions of complex linear differential-difference equations with coefficients having the same order, J. Math. Res. Appl. 34(6) (2014), pp. 683-695] and Belaidi [B. Belaidi, Growth of meromorphic solutions of finite logarithmic order of linear difference equations, Fasc. Math. 54(2015), pp. 5-20].

13. Some Properties of k-Gauss Hypergeometric Function by Sunil Joshi<sup>(1)</sup>, Ekta Mittal<sup>(2)</sup>, Shruti Dang<sup>(3)</sup> <sup>(1)</sup>Department of Mathematics & Statistics, Manipal University Jaipur <sup>(2,3)</sup> Department of Mathematics, The IIS University, Jaipur <sup>(1)</sup>sunil.joshi@jaipur.manipal.edu, <sup>(2)</sup>ekta.jaipur@gmail.com, <sup>(3)</sup>adang18aug@gmail.com

The main object of this paper is to develop the transformations of the k-hypergeometric function of the type  ${}_2F_{1,k}[(a, k), (b, k); (c, k); Z]$  for  $k \rightarrow 1$ , it will be converted in to know results. Further we also describe the k-gauss theorem and k-gauss hypergeometric equation and its solution with some interesting particular cases.

14. On Relative Deficiencies of Difference-Polynomials by Sukalyan Sarkar, Department of Mathematics, University of Kalyani Kalyani, Nadia - 741235 sukalyan-math.knc@gmail.com

In this paper, we compare the Valiron defect with the relative Nevanlinna defect of a particular type of differential-difference polynomial generated by a transcendental entire function.

## Section D : Functional Analysis

1. Properties  $(BR)$  and  $(BgR)$  for Bounded Linear Operators by Anuradha Gupta<sup>1</sup> and Ankit Kumar<sup>2</sup> <sup>1</sup>Department of Mathematics, Delhi College of Arts and Commerce University of Delhi, Netaji Nagar, New Delhi-110023, India <sup>2</sup>Department of Mathematics, University of Delhi, New Delhi-110007, India nktkumar065@gmail.com

In this paper we introduce the notion of property  $(BR)$  and property  $(BgR)$  for bounded linear operators defined on an infinite-dimensional Banach space. These properties in connection with Weyl type theorems and in the frame of polaroid operators are investigated. Moreover, we study the stability of these properties under perturbations by commuting finite-dimensional, quasi-nilpotent, Riesz and algebraic operators.

2. Coincidence point results in b-metric spaces via  $C_F$ -s-simulation function by Anuradha Gupta<sup>1</sup> and Manu Rohilla<sup>2</sup> <sup>1</sup>Department of Mathematics, Delhi College of Arts and Commerce University of Delhi, Netaji Nagar, New Delhi-110023, India <sup>2</sup>Department of Mathematics, University of Delhi, New Delhi-110007, India manurohilla25994@gmail.com

The main objective of the paper is to establish the existence and uniqueness of point of coincidence of a pair of self mappings in the setting of b-metric spaces via  $C_F$ -s-simulation function, covering the case of commuting and compatible mappings. This approach enables us to study several coincidence point and fixed point problems from a common perspective. The purpose is to unify, generalize and improve several existing results in b-metric spaces. An example with a corresponding numerical simulation is also provided to support the obtained result.

3. A fixed Point Theorem for the class of B-Contraction by Anushree A. Aserkar, Department of Applied Mathematics & Humanities Rajiv Gandhi College of Engineering and Research, Nagpur, India aserkar\_aaa@rediffmail.com

A fixed point theorem is established for the class of B-Contraction. We have generalized many results which are existing in the literature by introducing the concept of B-Contraction. An example is discussed to validate our result.

4. A Note on Fefferman-Stein's Weighted Lemmaby Duranta Chutia Department of Mathematical Sciences, Tezpur University, Tezpur durantachutia123@gmail.com

We prove an inequality similar to that of Fefferman-Stein's weighted lemma for a generalized one-sided maximal function with the help of one-sided Muckenhoupt weights. We also extend the result to the vector valued set up.

5. Solvability of the system of implicit generalized order complementarity problems by K. Mahalik Department of Mathematics, Indian Institute of Technology Kharagpur, India kartikiit1234@gmail.com

We introduce the notion of exceptional family for the system of implicit generalized order complementarity problems in vector lattice. We present some alternative existence results of the solutions for the system of implicit generalized order complementarity problems via topological degree. The new developments are generalization and improvement of some previous results.

6. Special Classes of Locally Convex Spaces Described as Inductive and Projective Limits by Santosh Kumar P.G. Department of Mathematics, Patna University, Patna, Bihar, India santoshrathore.kumar20@gmail.com

This paper manages a few parts of the theory of locally convex projective limits. Since the start of the theory of locally convex spaces, a fundamental gadget was to lessen inquiries in general spaces to the inquiries in easier or better-referred to spaces, for example, Banach or Frechet spaces. This methodology might be productive if the space under thought was developed out of those spaces. There is likewise a valuable theory managing last locally convex topologies that originate from topologies on certain convex subsets of a given vector space. A (LF)- space is an inductive breaking point of an arrangement of Frechet-spaces, a (LB)- space of a grouping of Banach-spaces. It is discovered that total locally convex spaces are those where a subspace of the double is feeble and closed if every one of its crossing points with equicontinuous set are frail and closed.

7. On spectra of permutative doubly stochastic matrices of order up to 4 by Amrita Mandal Department of Mathematics, Indian Institute of Technology

Kharagpur, India AMRITAMANDAL@iitkgp.ac.in

A permutative matrix is a matrix whose rows are permutations of its first row. A permutative doubly stochastic matrix is a nonnegative matrix which is both permutative and doubly stochastic. We prove that the eigenvalue region of the set of all  $4 \times 4$  permutative doubly stochastic matrices,  $\Lambda(\text{PDS}_4)$ , in  $\mathbb{C}$  is different from the eigenvalue region of set of all  $4 \times 4$  doubly stochastic matrices  $\omega_4$ . We construct two line segments which are in  $\omega_4$  but not in  $\Lambda(\text{PDS}_4)$ .

8. System of split variational inequality problems in semi-inner product spaces by Mohd Furkan University of Polytechnic, Aligarh Muslim University Aligarh, India mohdfurkan786@gmail.com

In this presentation, we introduce a new system of split variational inequality problems which is a natural extension of split variational inequality problem in semi-inner product spaces. We use the retraction technique to propose an iterative algorithm for computing the approximate solution of the system of split variational inequality problems. Further, the convergence analysis of the iterative algorithm is also discussed. Several special cases which can be obtained from the main result are also discussed.

6. Composition Operators on Certain Banach Subspaces of the Space of Holomorphic Mappings of Bounded Type by Deepika Baweja BITS Pilani, Hyderabad Campus, India deepika@hyderabad.bits-pilani.ac.in

In this talk, we consider the Banach subspaces  $\mathcal{H}_p^\gamma(E, F)$ ,  $1 \leq p \leq \infty$ , of the space  $\mathcal{H}_b(E, F)$  of holomorphic mappings of bounded type defined with the help of a particular type of entire function  $\gamma$ , known as a comparison function and defined as  $\gamma(z) = \sum_{n=0}^{\infty} \gamma_n z^n$ ,  $\gamma_n > 0$  for each  $n \in \mathbb{N}_0$  with  $\gamma_n^{\frac{1}{n}} \rightarrow 0$  and  $\frac{\gamma_{n+1}}{\gamma_n} \downarrow 0$  as  $n$  increases to  $\infty$ . For a suitably restricted comparison function  $\gamma$ , we will discuss some results concerning the boundedness and spectrum of the differentiation operator  $D_a$  acting between the spaces  $\mathcal{H}_p^\gamma(E)$ ,  $1 \leq p < \infty$ . Finally, we investigate the continuity and compactness of the composition operator  $C_\phi$ , defined corresponding to a holomorphic function  $\phi$ .

10. Spectral decomposition of lower triangular infinite matrices by Sanjay Kumar Mahto<sup>1,2</sup>, P. D. Srivastava<sup>3</sup> <sup>1</sup> Department of Mathematics, R. N. A. R. College Samastipur, India <sup>2</sup> Department of Mathematics, Indian Institute of Technology Kharagpur, India <sup>3</sup> Department of Mathematics, Indian Institute of Technology Bhilai, India skmahto0777@gmail.com

In this paper, a triple band infinite lower triangular matrix consisting of three oscillatory sequences is considered. The spectrum and its disjoint decompositions: point spectrum, continuous spectrum and residual spectrum of the matrix over the space  $c_0$  are determined. Further, the matrix is generalized to an  $n$ th band matrix consisting of  $n$  oscillatory sequences and an estimation of the spectrum is determined for this matrix over the same space  $c_0$ .

11. Common Fixed Point Theorem using new contractive condition in Multiplicative Metric Space by Manjusha P. Gandhi<sup>1</sup>, Anushri A. Aserkar<sup>2</sup> <sup>1</sup>Yeshwantrao Chavan College of Engineering, Nagpur <sup>2</sup>Rajiv Gandhi College of Engineering, Nagpur manjusha.g2@rediffmail.com

In the present paper, we discuss a unique common fixed point theorem for four mappings in multiplicative metric space which satisfy the new type of contractive condition. The mappings are considered as continuously sub-compatible in pairs to prove the fixed point. This theorem is extension and modification of results available in literature. An example has been given to validate the result.

12. On ranges and null spaces of a special type of operator named- $\lambda$ -jection by Rajiv Kumar Mishra Department of Mathematics Rajendra College Jai Prakash University, Chapra, Bihar dr.rkm65@gmail.com

In this article,  $\lambda$ -jection has been introduced which is a generalization of trijection operator as introduced in P. Chandra's Ph. D. thesis titled "Investigation into the theory of operators and linear spaces" (1977). We obtain relation between ranges and null spaces of two given  $\lambda$ -jection under suitable conditions.

## Section E : Differential / Integral / Functional Equations

1. Initial Value Problem for Dynamic Equations on Time Scales by Sanket Tikare<sup>1</sup>, Iguer Luis Domini dos Santos<sup>2</sup> <sup>1</sup> Department of Mathematics, Ramniranjan Jhunjhunwala College, Ghatkopar, Mumbai, India <sup>2</sup> Departamento de Matemática, Faculdade de Engenharia de Ilha Solteira, UNESP-Univ Estadual Paulista, Rua Rio de Janeiro, 266, Ilha Solteira São Paulo CEP 15385-000, Brazil sanket.tikare@gmail.com

This paper is concerned with the initial value problem for dynamic equations on time scales involving Carathéodory function. We offer existence and uniqueness of solutions to this initial value problem using Banach's fixed-point theorem. The nonlinear alternative of Leray-Schauder type is used to establish the existence of at least one solution. The paper also covers some properties concerning continuity and convergence of solutions.

2. Numerical solution of space-time fractional Burgers-Fisher and Burgers-Huxley equations by Anup Singh, Subir Das Department of Mathematical Sciences, Indian Institute of Technology (BHU) anup.singh254@gmail.com

The shifted Legendre collocation method is used to solve the one-dimensional nonlinear reaction-advection-diffusion equation having spatial and temporal fractional-order derivatives with initial and boundary conditions. The solution profiles of the normalized solute concentration of space-time fractional-order Burgers-Fisher and Burgers-Huxley equations are presented through graphs for different particular cases. The main purpose of the article is the graphical exhibition of the effect of the temporal, spatial fractional-order derivatives and the reaction term on the solution profile of the space-time fractional-order Burgers-Fisher and Burgers-Huxley equations. The other purpose of the article is the error estimation of the proposed method. A drive has been taken to validate the effectiveness of the proposed method through tabular presentation of comparison of numerical results with analytical results for the existing problems through convergence analysis.

3. Existence the Solution for Fractional Order Differential Equation by B.D. Karande Department of Mathematics Maharashtra Udayagiri Mahavidyalaya Udgir - 413517, Maharashtra, India bdkarande@rediffmail.com

In this Paper we have to prove that the existence the solution for a fractional order nonlinear quadratic differential equation with initial value condition in banach algebras. Moreover; we show that solutions of this equation are locally attractive. We make use of the standard tools of the hybrid fixed point theory for two operators to establish the main result. The existence theorems for extremal solutions are also proved under certain monotonicity conditions.

4. Group Analysis of the One Dimensional Wave Equation With Delay by Jervin Zen Lobo Department of Mathematics, St. Xavier's College Mapusa, Goa 403507, India zenlobo1990@gmail.com

In this paper, we establish a Lie type invariance condition for second order delay partial differential equations. The determining equations are obtained using Taylor's theorem for a function of several variables. The symmetries of the wave equation with delay, its kernel

and extensions of the kernel have been found. We make a complete group classification of the wave equation containing an arbitrary differentiable functional with delay, for which there is no existing literature. Further, the complete set of invariant solutions led by this classification have been found.

5. **Finite difference scheme for electromagnetic waves model arising from dielectric media** by Rahul Kumar Maurya Department of Mathematical Sciences Indian Institute of Technology (BHU), Varanasi, India rahulkm.rs.mat16@itbhu.ac.in

In this work, we apply a stable numerical scheme for the solution of two dimensional quasi-linear fractional differential waves model (2D FDWM) with Dirichlet boundary condition arising from dielectric media. The proposed method is based on a finite difference scheme in time. The Caputo's fractional derivative in time is approximated by a difference scheme of , and the Laplacian operator is approximated by central difference discretization. Finally, the proposed numerical scheme convert the 2D FDWM into pentagonal system. The unconditional stability for the proposed scheme is derived and convergence analysis is investigated through optimal error bound. The optimal order of convergence is obtained for 2D FDWM numerical scheme, where  $1 < \beta < \alpha < 2$ . Numerical results are included to verify the accuracy and efficiency of the proposed scheme.

6. **Analytical solution of non-linear initial value fractional order differential equations with Caputo derivative** by Pratibha Verma Department of Mathematics Motilal Nehru National Institute of Technology Allahabad Prayagraja 211004, Uttar Pradesh, India pratibhaverma@mnnit.ac.in

The main focus of this study is to apply the Two-step Adomian decomposition method to solve the non-linear differential equation for fractional order using the Caputo derivative. We are interested to get an analytical solution without any difficulty with less iteration and without converting the nonlinear fractional differential equations to a system of linear algebraic fractional equations. Here, we consider four examples to demonstrate the Two-step Adomian decomposition method and compared with Adomian decomposition method and combination of the spectral method. We conclude that Two-step Adomian decomposition method is provides the exact solution of non-linear differential equation of fractional-order while other methods give approximate solution.

7. **Solitary Wave Solutions of Few Nonlinear Evolution Equations** by A.K.M. Kazi Sazzad Hossain Department of Mathematics, Begum Rokeya University Rangpur, Bangladesh kazi.bru@yahoo.com

The solitary wave solutions of nonlinear evolution equations (NLEEs) is being an attractive subject in the field of physical sciences and engineering. In this article, we have investigated advance solitary wave solutions of three important nonlinear equations such as via simplified MCH equation, Pochhammer-Chree (PC) equation and Schrodinger Hirota equation by using modified simple equation (MSE) method. These equations play an important role in the study of nonlinear sciences. The obtained solutions are expressed in terms of exponential and trigonometric functions including solitary and periodic solutions. It is shown that the obtained solutions are more general and fresh and can be helpful to analyze the NLEEs in mathematical physics.

8. **Generalized and Mixed Synchronization of Different Chaotic and Hyperchaotic Systems via OPCL Coupling** by Mohammad Ali Khan Department of Mathematics, Ramananda College Bishnupur, West Bengal, India mdmaths@gmail.com

One of the most striking discoveries in the study of chaos is that chaotic systems can be made synchronized with each other. Synchronization of chaos is a phenomenon that may occur when two or more chaotic dynamical systems are coupled. There are different type

of generalized synchronization method have studied earlier. But here we propose different schemes for generalized and mixed synchronization of different chaotic and hyperchaotic systems using open-plus-closed-loop (OPCL) coupling (unidirectional as well as bidirectional). Numerical simulation results are presented to show the efficiency of our proposed schemes.

9. Controllability Results for Abstract Integro Evolution System with Non-instantaneous Impulses over Time Scales by Vipin Kumar, School of Basic Sciences Indian Institute of Technology Mandi, India math.vipinkumar219@gmail.com

Our purpose in this manuscript is to study the exact controllability results for an abstract integro evolution system with non-instantaneous impulses over time scales. Evolution operator theory, Banach fixed point theorem and nonlinear functional analysis have been used to establish these results. Finally, some theoretical and numerical examples are given to illustrate the application of these results.

10. Existence and Uniqueness of Weighted Pseudo Almost Automorphic Solution for Sobolev-type Differential Equations on Time Scales by Soniya Dhama, School of Basic Sciences Indian Institute of Technology Mandi, India soniadhama.90@gmail.com

Our paper is dedicated to look at the existence, uniqueness consequence of weighted pseudo almost automorphic ( $WPA$ ) solution for sobolev-type differential equation on time scales by applying fixed point hypothesis. Toward the last, a numerical example is given for the adequacy of the hypothetical outcomes.

11. Existence of solutions of Retarded Nonlocal Stochastic Impulsive Delay Differential Equations driven by Rosenblatt process by Tamil Selvan. T, Department of Mathematics with Computer Applications PSG College of Arts & Science, Coimbatore 14, Tamilnadu, India tamilmath94@gmail.com

Present work reports the existence results for solutions of Retarded Nonlocal Stochastic Impulsive differential equations driven by Rosenblatt process with infinite delay. The existence is proved with the aid of fixed point techniques.

12. A new approach of operational matrices for weakly singular nonlinear partial differential equations by Somveer Singh, Department of Mathematical Sciences, Banaras Hindu University rathaurbhu.90@mail.com

A new approach based on operational matrices of multi-wavelets is introduced for solving weakly singular nonlinear partial differential equations (SNPDEs). Operational matrices of multi-wavelets are derived and utilized to transform the given SNPDE into the nonlinear system of equations by combining collocation method. Convergence analysis and error estimation the presented technique are also investigated. Some numerical experiments are performed to demonstrate the validity and applicability of the method.

13. Existence and Uniqueness Results of Impulsive Fractional Neutral Pantograph Integro- Differential Equations by R. Ilavarasi, K. Malar, Department of Mathematics, Erode Arts and Science College, Erode, Tamil Nadu, India ilavarasi99ravi@gmail.com

In this paper, the existence and uniqueness results for fractional Impulsive neutral pantograph integro-differential equations with delay. The results are obtained by using the fixed point theorem. An example is provided to illustrate the main results.

14. Symmetry Analysis and Optimal Systems of Generalized Chaplygin Gas Equations with a Source Term by Pabitra Kumar Pradhan, Manoj



Pandey Department of Mathematics, Birla Institute of Technology and Science Pilani, Goa 403726, India pabitr58@gmail.com

The system of generalized Chaplygin gas equations with a coulomb-like friction term has been investigated by using the famous Lie symmetry method. A direct and systematic algorithm based on the adjoint transformation and invariants of the admitted Lie algebras are then used to construct one and two-dimensional optimal system of the Chaplygin gas equations. An inequivalent class of group invariant solutions are then obtained using the one-dimensional optimal system, further the evolutionary behavior of the weak discontinuity wave within the state characterized by one of the group invariant solutions is investigated in detail, and certain observations are noted in respect to their contrasting behavior.

**15. Non-Instantaneous Impulsive Fractional Neutral Functional Stochastic Integro-Differential System with Measure of Non-compactness** by K. Malar, Department of Mathematics, Erode Arts and Science College Erode - 638009, Tamil Nadu malarganesaneac@gmail.com

This article focuses on existence results of fractional order stochastic non-instantaneous impulsive neutral functional integro-differential equation with infinite delay. The results are obtained by using the Hausdorff measure of non-compactness, fractional calculus, stochastic analysis techniques and fixed point theorems. At the end of this article, a suitable example is given and justified with our results.

**16. Consequences of Psychological impact on Insurgents in a Counter Insurgency Operation under Decapitation Warfare involving Range-Dependent Attrition-Rate Coefficients** by Lambodara Sahu Department of Mathematics, Faculty of Civil Engineering College of Military Engineering, Pune - 411031 lsahucme@gmail.com

Nowadays, using modern technology the forces so called security forces and insurgents are engaged in confrontation with various decapitation strategies comprising undermining operation and ground combat. Considering the objective of the forces, the ground combat may be further subdivided to decapitation combat and regular combat. A counter insurgency operation by the security forces may be considered as good as a regular combat with smaller strength involving undermining operations such as precision strike, missile attack, etc., against insurgents to nullify their various decapitation strategies. The concept of Lanchester's equations is significant in representing battle model of a counter insurgency operation. In addition, suitable probabilities have been assumed to take into account the psychological impact on the insurgents making the situation more realistic, which helps the military leaders to be more tactical for bringing down the operation into a short time frame with less casualties of security forces inflicting more to insurgents.

However, Range-dependent attrition-rate coefficients involving maximum effective range of the forces incorporated with the decapitation effect multipliers may also be the primary constituents of the model to show the efficiency of combat power transformation for causing attrition to the opposing side.

## Section F : Geometry

**1. Geometry of Warped Product Lightlike Submanifolds of Indefinite Nearly Kaehler Manifolds** by Sangeet Kumar Department of Mathematics, SGTB Khalsa College Sri Anandpur Sahib - 140018 sp7maths@gmail.com

Warped product manifolds are generalization of Riemannian product manifolds. For instance, a surface of revolution is a warped product manifold. This class of manifolds have extensive uses in differential geometry and mathematical physics. For example, the

warped product manifolds provide an excellent setting to model space time near black holes or bodies with large gravitational field. Moreover, many solutions to Einstein's field equations are expressed in terms of warped products. Therefore, in this paper, we study geometry of warped product  $GCR$ -lightlike submanifolds of indefinite nearly Kaehler manifolds. We prove the non-existence of warped product  $GCR$ -lightlike submanifolds of the type  $N_{\perp} \times_f N_T$  in an indefinite nearly Kaehler manifold. Then, we prove the existence of  $GCR$ -lightlike warped product submanifolds of the type  $N_T \times_f N_{\perp}$  in indefinite nearly Kaehler manifolds by developing a characterization in terms of the shape operator. We also derive some necessary and sufficient conditions for a  $GCR$ -lightlike submanifold of an indefinite nearly Kaehler manifold to be a  $GCR$ -lightlike warped product submanifold.

2. Some characterizations of slant submanifolds of trans-Sasakian manifolds by Avijit Sarkar Department of Mathematics, University of Kalyani av-jaj@yahoo.co.in

The object of the present paper is to study slant submanifolds of trans-Sasakian manifolds with second fundamental form satisfying certain conditions. Totally umbilical slant submanifolds of trans-Sasakian manifolds have been considered. Nature of slant submanifolds of transSasakian manifolds as Ricci soliton has also been analyzed.

3. Kaehlerian Spaces Admitting in H-Projective Vector Field with Constant Scalar Curvature by U.S. Negi H.N.B. Garhwal (A Central) University S.R.T. Campus Badshahi-Thaul, Tehri Garhwal 249199 usnegi7@gmail.com

Ishihara (1959) has studied holomorphically projective changes and their groups in an almost complex manifold and also proved on holomorphic planes. Obata (1965) has defined and studied Riemannian manifolds admitting a solution of a certain system of differential equations. In this paper, we have defined and studied Kaehlerian spaces admitting in H-projective vector field with constant scalar curvature and several theorems have been proved. Also, then find necessary and sufficient conditions for such a Kaehlerian space to be isometric to a complex projective space with Fubini-Study metric.

4. Semi-invariant Submanifolds of Generalized  $(\kappa, \mu)$  space-forms by Sujoy Ghosh Department of Mathematics, University of Kalyani, West Bengal, India sujoy0008@gmail.com

In differential geometry, submanifold theory has become a growing topic of research. The idea of "submanifold" forms the most outstanding concept in differential geometry and plays an important role in the development of the subject. The object of the present paper is the study of Semi-invariant submanifolds of generalized  $(\kappa, \mu)$  space-forms. Present paper reports their principal characteristics and the particular cases in which the manifold is generalized  $(\kappa, \mu)$  space. This paper also present some results for semi-invariant submanifolds of a generalized  $(\kappa, \mu)$  space-forms.

## Section G : Topology

1. Minimally Supported Frequency(MSF)  $d$ -dilation Wavelets by Aparna Vyas Department of Mathematics, Manav Rachna University, Faridabad, India aparna.vyaas@gmail.com

In this paper, we provide a geometric construction of a symmetric  $2n$ -interval minimally supported frequency(MSF)  $d$ -dilation wavelet set with  $d \in (1, \infty)$  and characterize all symmetric  $d$ -dilation wavelet sets. We also provide two special kinds of symmetric  $d$ -dilation wavelet sets, one of which has  $4m$ -intervals whereas the other has  $(4m + 2)$ -intervals, for  $m \in \mathbb{N}$ . In addition, we construct a family of  $d$ -dilation wavelet sets which has an infinite number of components.

2. Some new Concepts in Fuzzy Bitopological Spaces by Md. Ruhul Amin<sup>1</sup>, Md. Sahadot Hossain<sup>2</sup> <sup>1</sup>Department of Mathematics, Faculty of Science, Begum Rokeya University, Rangpur - 5404, Bangladesh <sup>2</sup>Department of Mathematics, Faculty of Science, University of Rajshahi, Rajshahi - 6205, Bangladesh ruhulbru1611@gmail.com

In this paper, we have defined some new notions of  $\alpha$ -separation in fuzzy bitopological spaces using quasi-coincidence sense. We have discuss the relations among our and other such notions. We have observed that all these notions satisfy good extension property. We have shown that these notions are preserved under the one-one, onto and FP-continuous mapping. Moreover, we have obtained productivity and some other properties of this new concept. Initial and final topologies are studied here in quasi-coincidence sense.

3. On Some Convergences of Multifunctions and Slight  $B^*$ -continuity by Chandrani Basu Department of Mathematics, South Asian University, New Delhi, India chandrani.basu@gmail.com

Continuity and its various weaker and stronger forms for functions as well as multifunctions are the fundamental notions in the general topology and analysis. Consequently, different types of convergences have been studied which preserve these generalized continuities. In 1995, Kupka and Toma defined the concept of strong convergence for net of multifunctions and later on Domnik proved that strong convergence preserves upper and lower semi continuity. Ganguly and Mallick gave the notion of  $c$ -convergence and some sufficient conditions under which this type of convergence preserves further generalized continuity, namely,  $\varepsilon$ -continuity.

In this presentation we discuss the concepts of  $\tau_{cl}^+$  and  $\tau_{cl}^-$ -pointwise convergence, upper and lower  $cl$ -convergence and nearly-strongly convergence of nets of multifunctions from one topological space to another and compare them. Attempt has been made to formulate sufficient conditions under which these convergences preserve slight  $B^*$ -continuity of the limit multifunction.

4. Approximation of Fixed Points of Nonexpansive Mappings on Hadamard Spaces by Javid Ali, Department of Mathematics, Aligarh Muslim University, Aligarh, India javid.mm@amu.ac.in

In this presentation, we recall some fundamental fixed point theorems and notion of Hadamard space (complete CAT(0) space) with basic properties. We prove some strong convergence and  $\Delta$ -convergence results to approximate the fixed of multi-valued nonexpansive mappings on CAT(0) spaces via one step iterative scheme. We also prove some results without end point condition. As an application, we study image recovery problem in CAT(0) spaces.

5. Annulets in a 0-distributive Lattice by R.M. Hafizur Rahman Department of Mathematics, Faculty of Science, Begum Rokeya University, Rangpur, Bangladesh salim030659@yahoo.com

The set of all ideals of the form  $\langle a \rangle$ , are known as annulets of  $L$ . These have been studied extensively by Cornish for distributive lattices. In this paper we have studied the topic only for  $\alpha$ -distributive lattices.

6. A short proof of the metrizability of  $\mathcal{F}$ -metric spaces by Sumit Som Department of Mathematics, National Institute of Technology Durgapur, India somkacd-wip@gmail.com

The main purpose of this manuscript is to provide a short proof of the metrizability of  $\mathcal{F}$ -metric spaces introduced by Jleli and Samet [*On a new generalization of metric spaces*, J. Fixed Point Theory Appl. **20**(3)(2018)].

7. A study on some variations of I-Hurewicz property using star-selection principles by Upasana Samanta, Department of Mathematics, Jadavpur University, Kolkata, India samanta.upasana@gmail.com

In this paper, the main point of consideration is I-Hurewicz property which was introduced by Prof. Das and plays an important role in the study of selection principles and covering properties for the last decade. Subsequently, star-versions of I-Hurewicz property are introduced along with its two variants and analyze these properties in terms of selection principles. Certain interrelationships between these new notions are established and suitable examples are constructed. Several related results and, in particular, preservation properties are studied.

8. The Critical Point Equation on Kenmotsu and almost Kenmotsu manifolds by Dhriti Sundar Patra, Department of Mathematics, Birla Institute of Technology Mesra, Ranchi 835215, India dhritimath@gmail.com

In this work, we have studied the critical point equation (shortly, CPE) within the framework of Kenmotsu and almost Kenmotsu manifold satisfying certain nullity conditions. First, we prove that a complete Kenmotsu metric satisfies the CPE is Einstein and locally isometric to the hyperbolic space  $H^{2n+1}$ . In case of Kenmotsu manifolds, it is possible to determine the potential function explicitly (locally). We also provide some examples of Kenmotsu and almost Kenmotsu manifolds that satisfies the CPE.

9. Generalized Forms of I-Continuous Maps in Binary Ideal Topological Spaces with Applications by Nazir Ahmad Ahengar, Department of Mathematics and Computer Science R.D. University, Jabalpur 482001 nzrhmd97@gmail.com

The concept of binary topology from  $X$  to  $Y$  and the concept of topology on are independent and have been aroused as the new concept in the field of topology and have several applications in the modern science. In this paper we introduce and study several generalized forms of continuous maps in generalized binary ideal topological spaces like  $\alpha$ -semi-continuous maps,  $\beta$ -semi-continuous maps, totally-semi-continuous maps and strongly  $\alpha$ -semi-continuous maps and investigate various relationships of these maps by making the use of some counter examples. The study has not been found to be useful only in the categorization of the new class of generalized sets in generalized ideal topology but also establishing the relationships in the different useful fields of life.

10. Fuzzy metric representing crisp metric by R. Roopkumar, Department of Mathematics, Central University of Tamil Nadu, Thiruvavur, India roopkumarr@rediffmail.com

For a given fuzzy metric  $M$ , we introduce two different nets  $(\Delta_{M,\lambda})$  and  $(\delta_{M,\lambda})$  of metrics constructed from the fuzzy metric  $M$ , and prove that both nets converge to the same limit, under some necessary and sufficient condition. The common limit is called the actual metric representing the fuzzy metric  $M$ . We also derive some of the properties of these approximate metrics  $\Delta_{M,\lambda}$  and  $\delta_{M,\lambda}$ . On the other hand, for a given a metric  $d$ , we establish that the fuzzy metric representing  $M_d$  with values in  $\{0, 1\}$  and  $d$  are compatible with the same topology. Further, we prove that if a metric  $d$  induces a fuzzy metric  $M_d$ , then all the approximate metrics  $\Delta_{M,\lambda}$  and  $\delta_{M,\lambda}$  constructed from this fuzzy metric are equal to the original metric  $d$ .

## Section H : Measure Theory, Probability Theory and Stochastic Processes, and Information Theory

1. Beta Seasonal Autoregressive Fractionally Integrated Moving Average Models by Mohammad Shad, Department of Mathematics, NIT Hamirpur, India

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In this paper we have developed a dynamic beta seasonal autoregressive fractionally integrated moving average model based on the class of beta regressions. This model can be used to predict seasonal time series data which assume value in the standard unit interval  $(0, 1)$  such as rates and proportions. We estimated parameters of the proposed model using conditional maximum likelihood method. The closed form expression for the conditional score vector and conditional Fisher information matrix were derived. This paper also discuss about the interval estimation, hypothesis testing, model selection and forecasting. Monte Carlo simulation has been used to obtain the finite sample performance of conditional maximum likelihood estimators and white noise test. An application to environmental real data is also presented and discussed.

2. **An uncountable, measure zero, dense set of non-monotone points of continuous functions** by R. Palanivel Department of Mathematical and Computational Sciences National Institute of Technology Karnataka, Suarthkal, Mangalore 575025, India palanivelmath92@gmail.com

In this paper, we present a continuous function which has every Cantor ternary point as its non-isolated non-monotone points. The union of all the sets of non-isolated non-monotone points of iterates of the function have the desired properties.

3. **New fractional integral inequalities** by Atanu Manna Assistant Professor of Mathematics, Indian Institute of Carpet Technology Chauri Road, Bhadohi-221 401, Uttar Pradesh, India atanu.manna@iict.ac.in

The classical Hardy's integral inequality and its extensions play an important role in various branches of mathematical analysis. In this short note, a new proof is obtained of a famous extension of classical Hardy's integral inequality. Indeed, a basic concept of probability theory has been applied to establish it. Using similar techniques, certain new fractional integral inequalities involving generalized *Riemann-Liouville* and *Weyl* integrals are established. It is also shown that the best possible constants in each of the above inequalities can be obtained by a probabilistic method.

## Section I : Numerical Analysis, Approximation Theory and Computer Science

1. **A uniformly convergent method for a two parameter singularly perturbed parabolic problem with time delay** by Sumit, Sunil Kumar Department of Mathematical Sciences, Indian Institute of Technology (BHU) Varanasi, India sumit.rs.mat16@iitbhu.ac.in

We construct a robust numerical method for a two parameter singularly perturbed parabolic problem with time delay using a hybrid monotone finite difference operator on an adaptive mesh. The mesh used is a product of uniform mesh in time and a piece-wise uniform Shishkin mesh in space variable. The method is proved to be second order parameter uniformly convergent in space and first order in time.

2. **DPG Method with Optimal Test Functions for the Heat Equation** by Jhuma Sen Gupta Department of Mathematics, BITS Pilani Hyderabad Campus, Hyderabad, Telangana jhumagupta08@gmail.com

In this talk, we discuss discontinuous Petrov-Galerkin (DPG) method with optimal test functions for the heat equation. We have considered a time stepping scheme based on the backward Euler approximation and ultra-weak variational formulation at each time step. We discuss the stability of the method for both the field variables (the original unknown and its gradient weighted by the square root of the time step) and present a framework

for abstract error analysis to derive a C ea-type error estimate. Finally, some numerical results are reported to validate our theoretical findings.

3. Degree of Approximation of Conjugate Fourier Series of Functions in Besove Space by Riesz Mean by Sanghamitra Beuria Department of Mathematics, College of Basic Science and Humanities, OUAT, Bhubaneswar, Odisha sbeuria108@gmail.com

The paper studies the degree of approximation of functions by their Conjugate Fourier series in the Besove space by Riesz mean and thus generalizing many known results.

4. Direct and inverse results for Kantorovich type exponential sampling series by Shivam Bajpeyi Department of Mathematics, Visvesvaraya National Institute of Technology Nagpur, Nagpur, India. shivambajpai1010@gmail.com

In this article, we analyse the approximation properties of the new family of Kantorovich type exponential sampling series. We obtain the point-wise approximation theorem and Voronovskaya type theorem for the proposed operator. Further, we obtain a representation formula and an inverse result approximation for the above family of operators. Finally, we give some examples of kernel functions to which the proposed theory can be applied along with the graphical representation exhibiting the approximation by this operator.

5. Approximation of functions in Besov space by Supriya Rani Department of Mathematics, Central University of South Bihar Gaya - 824236 (Bihar), India supriya@cusb.ac.in

The degree of approximation of a function in Lipschitz space, H older space and generalized H older space using single and product summability operators has been studied by the some earlier authors. In the present work, we estimate the error of a function  $g$  in Besov space using Hausdorff-generalized N rlund  $(\Delta_H \cdot N^{p,q})$  product operator of its Fourier series. It is interesting to note that Besov space generalizes different functional spaces like Sobolev space, Lipschitz space and generalized H older space. Besov space is also used to study regularity properties of the functions. It can also be noted that the product operator is stronger than a single summability operator. Thus, in the present work, we consider Hausdorff-generalized N rlund  $(\Delta_H \cdot N^{p,q})$  means product operator  $(\Delta_H \cdot N^{p,q})$  means reduces to  $E_q \cdot N^{p,q}$ ,  $C_1 \cdot N^{p,q}$ ,  $\Delta_H \cdot N^{pm}$ ,  $\Delta_H \cdot N^{1/(m+1)}$ ,  $\Delta_H \cdot \bar{N}_{q_m}$ ,  $\Delta_H \cdot C_\alpha$  means. In fact, in the present work, we establish two theorems on best approximation of a function  $g$  belonging to  $B_q^\lambda(L_r)$  space using  $\Delta_H \cdot N^{p,q}$  product means of its Fourier series. Our results generalizes three known results of this direction of work.

6. ElNino based Comparison of Learning Algorithms for Modeling Annual Rainfall in Chennai by M. Nirmala Department of Mathematics Sathyabama Institute of Technology, Chennai, India mnirmalamaths@gmail.com

The prediction of annual rainfall is very important because of current climate change and for the disaster management in a metropolitan city like Chennai, India. Present work reports comparison of prediction models for the annual rainfall in Chennai through learning algorithms of Artificial Neural Network (ANN). For this purpose, a dataset consisting of monthly rainfall of Chennai and Nino3.4 from 1901 -2017 were collected and Multilayer Perceptron (MLP) and Radial Basis function (RBF) algorithms were applied to model the annual rainfall. The suitable model is identified by measuring the performance of the models using the error measures.

7. A Study of approximation by linear combinations of Lupas operators by Avinash Kumar Sharma P.G. Deptt. of Mathematics Magadh University, Bodh Gaya, Bihar ak95257016@gmail.com

It has been established by Karovkin's theorem that operators sequence introduced by A. Lupas is an approximation method. In this paper we have shown that, under certain constraints on functions, linear combinations of operator sequence of A. Lupas behave better as regards convergence. We have found an expression for moments of general order. These play a crucial role. We use it to prove our main result.

8. Kantorovich-type non-linear exponential sampling series in the setting of Orlicz spaces by Prashant Kumar Department of Mathematics Visvesvaraya National Institute of Technology Nagpur, Nagpur, India. pranwd92@gmail.com

In the present article, we introduce a non-linear version of the Kantorovich type exponential sampling operators and study its convergence in the setting of Orlicz spaces. We derive the point-wise and uniform convergence results for the above operator. The problem of convergence for the proposed operator is discussed in some particular function spaces like exponential spaces, logarithmic spaces etc. Finally, some examples of the kernel functions to which the theory can be applied along with graphical representation are provided.

9. Numerical Solution of Elliptic Dirichlet-Robin Initial Boundary Value problem on Square and Triangular Domain by Malabika Adak Department of Applied Mathematics and Humanities, Yeshwantrao Chavan college of Engineering, Nagpur, India malabikaadak@yahoo.co.in

Laplace and Poisson equation is a typical second order elliptic partial differential equation (PDE) that appears in many areas of science and engineering. Five-point finite difference method (FDM) is used to solve the twodimensional Laplace and Poisson equations on square and triangular domain. To solve partial differential equation specific boundary conditions are required. In this study, Dirchlet and Robin boundary conditions are considered for solving the system of equations at each iteration. When the function itself is specified on the boundary is called Dirichlet boundary. In some problems, a linear combination of function and its normal derivative is specified, is called Robin boundary. The chosen body is square and triangle, which is discretized into square grids and non-square grids particularly for triangular domain. The obtained numerical results are compared with analytical solution. The study objective is to check the accuracy of FDM for the numerical solutions of square and triangular bodies of 2D Laplace and Poission equations.

10. A New Two-steps Iterative Scheme Based on Composite Simpsons Rule for Solving Nonlinear Equations by Jogendra Kumar DIT University, Dehradun, U. K., India jogendra.bhu@gmail.com

In this paper, a new two-steps iterative method of order three constructed based on composite Simpson rule and fundamental theorem of calculus for solving nonlinear equations. A number of numerical examples are given to show the efficiency and performance of the method. Also the method is compared with some well-known existing iterative methods.

11. Comparison of two hybrid iteration schemes based on proper double splittings by Ashish Kumar Nandi Department of Mathematics BITS Pilani K.K. Birla Goa Campus, Goa, India ashish.nandi123@gmail.com

The purpose of this work is to formulate two hybrid alternating methods by using double proper splittings. This work is motivated by Benzi and Szyld [Numerische Mathematik 76 (1997) 309-321; MR1452511]. The first scheme extends the scheme in the non-singular matrix setting introduced by Li, Fan, and Zheng [Comput. Math. Appl. 77 (2019) 981990; MR3913644] very recently and then a second hybrid scheme is proposed such that the classes of matrices, for which the performance of one hybrid scheme is better than the other, are mutually exclusive. The double splitting outperforms the single spitting, even

for rectangular matrices. Also, the hybrid schemes are faster and has several computational advantages over the classical splitting methods. Further, we have discussed the performance of the pre-conditioners induced by two different double alternating schemes. The convergence and comparison results are discussed with computational evidences, which ensure the faster convergence of hybrid schemes than the usual double splitting method. The theoretical findings are verified by numerical examples.

12. A study on approximation of a conjugate function using Cesàro-Matrix product operator by H.K. Nigam<sup>1</sup>, Md. Hadish<sup>2</sup> Department of Mathematics, Central University of South Bihar, Gaya hadish@cusb.ac.in

In this paper, we, establish two theorems to study the error estimates of conjugate of a function  $f$  ( $2\pi$ -periodic) in weighted Lipschitz class  $W(L^p, \xi(t))$ , by cesàro-Matrix ( $C^\delta T$ ) product means of its conjugate Fourier series. In this work, we consider more advance class of function as compared to the work of earlier authors in order to arrive at the best approximation of conjugate of a function  $f$  ( $2\pi$ -periodic) by trigonometric polynomial of degree  $n$ . It can be noted that the results obtained so far in the direction of present work could not provide the best approximation of the function. Also, the studies on estimations of error of conjugate of a function  $f$  ( $2\pi$ -periodic) in weighted Lipschitz class  $W(L^p, \xi(t))$  using  $C^\delta T$  means of conjugate Fourier series have not been studied so far. Our results generalize six previously known results and also provide some important corollaries.

13. On the Location of Zeros of a Polynomial (*with Quaternionic Variable*) by D. Tripathi Department of Mathematics, Manav Rachna University, Faridabad, India dinesh@mru.edu.in

Let  $p(q) = \sum_{l=0}^n q^l a_l$ , where  $q = \alpha + i\beta + j\gamma + k\delta \in \mathbb{H}$ , where  $\alpha, \beta, \gamma, \delta \in \mathbb{R}$  and  $i, j, k$  are the fundamental quaternion units and  $a_l, 0 \leq l \leq n$  are either real or quaternions. In this paper, we present certain results concerning the location of zeros of polynomial  $p(q)$  with quaternionic variable  $q$ , which generalize and refine some known Eneström-Kakeya type bounds.

14. Higher order fitted operator numerical scheme for singularly perturbed delay differential equations by S. Dinesh Kumar School of Advanced Sciences, VIT Vellore mathdinesh005@gmail.com

In this paper, we consider a boundary value problem for a singularly perturbed delay differential equation of reaction-diffusion type. A fitted operator finite difference scheme based on Numerov's method is constructed. The scheme derived is a fourth order accurate for a moderate value of the perturbation parameter, whereas for small values of the parameter the method is second order or less. An extensive amount of computational work has been carried out to demonstrate the applicability of the proposed method.

## Section J : Operations Research

1. Multi-Objective Fractional Programming with Real-Coded Genetic Algorithm for Optimization with Real Data by Debasish Roy, Department of Mathematics, IIT Kharagpur, West Bengal 721302, India debasish.roy@maths.iitkgp.ac.in

Real-Coded Genetic Algorithm handles the alleles by a real number in comparison to the Canonical Genetic Algorithm, which processes them by binary numbers. RCGA (Real-Coded Genetic Algorithm) is a closer solution for real-world problems. In this paper, RCGA has been implemented in MATLAB. The financial statements of a Tea Firm were analysed, and the data was extracted. Two ratio functions have identified to characterise the problems of Tea Estate. The coefficients of the model have been derived by Regression



Analysis on historical data using R programming. Improvement of these functions will inherently enhance the efficiency of the organisation. Here the multivariate vector function in  $R^2 +$  will be optimised. The principles of Multi-Objective Optimizations have been used to optimise the two objective functions. The most generic way in MOOP is a Genetic Algorithm. Therefore, the optimal value of the vector function is derived with the help of a Genetic Algorithm with real values. The results are also presented with intermediate steps.

2. Optimum Production for a heaped stock dependent breakable item through variational principle by J.N. Roul, Patha Bhavana, Visva-Bharati, Santiniketan-731235, West Bengal, India jotindranath.roul@visva-bharati.ac.in

Breakability rate of fragile item depends on the accumulated stress of heaped stock level. So breakability rate can be considered as dependent parameter of stock variable. The unit production cost is a function of production rate and also dependent on raw material cost, development cost and wear-tear cost. The holding cost is assumed to be non-linear, dependent on time. Here optimal control problem for a fragile item under finite time horizon is considered. The profit function which consists of revenue, production and holding costs is formulated as a Fixed-Final Time and Fixed State System, optimal control problem with finite time horizon. Here production rate is unknown and considered as a control variable and stock level is taken as a state variable. It is formulated to optimize the production rate so that total profit is maximum. As particular cases, models are evaluated with and without breakability. The models are solved by using conventional Variational Principle along with the non-linear optimization technique-Generalised Reduced Gradient Method (LINGO 12.0). The optimum results are illustrated both numerically and graphically. Some sensitivity analysis on breakability coefficient are presented.

3. Markovian Queueing Model with Second Optional Service and Correlated Reneging by P. Vijaya Laxmi Department of Applied Mathematics, Andhra University, Visakhapatnam 530003, India vijaya\_iit2003@yahoo.co.in

In this paper, we study a single server Markovian queueing system with second optional service and correlated reneing. The system is analyzed by a quasi birth-death process and steady state probabilities of the model are obtained using matrix geometric method. Some performance measures and numerical illustrations are also provided. An optimization of the cost function is performed to find the optimal service rate that minimizes the total cost.

4. An optimization approach to airline crew pairing problems by Tanmay Kundu, Deepmala Mathematics Discipline PDPM Indian Institute of Information Technology, Design and Manufacturing Jabalpur- 482005, India tanmaykundu.math@gmail.com

In airline industry, an effective crew scheduling system is essential for reducing operating costs and it is the second largest direct operational cost next to the fuel costs. Crew scheduling consist of two problems: crew pairing and crew assignment. In crew pairing phase, anonymous pairings, starting and ending at a home base, are constructed. In total, the pairings must cover all positions to be covered in the flights defined by the time table. Besides the fuel costs a considerable portion of the crew costs can be saved through solving the crew pairing optimization problem. In this paper, we propose a brief review and mathematical model of the fundamental crew pairing problem, its concepts, algorithms, and computation.

5. Fuzzy programming with S shaped nonlinear membership function approach to multiobjective solid transportation problem with mixed constraints by A.K. Bit Department of Mathematics, Faculty of Civil Engineering College of Military Engineering, Pune - 411 031 (M.S.), India amalkbit@yahoo.com

The multiobjective solid transportation problem with mixed constraints in which the supply, demand and capacity constraints are mixed (equality and inequality) types and the objectives are equally important, non-commensurable and conflicting in nature. The fuzzy programming with S shaped nonlinear membership function for obtaining efficient solutions as well as the best compromise solution of a multiobjective solid transportation problem with mixed constraints has been presented in this paper. An example is included to illustrate the methodology. In addition, this method is compared with one existing fuzzy programming algorithm with linear membership function and hyperbolic membership function using one example.

## **Section K : Solid Mechanics, Fluid Mechanics, Geophysics and Relativity**

1. A Comparative Analysis of Magnetothermoelastic Disturbances induced by Thermal Shock in Three Phase Lag Theory of Thermoelasticity and Dual Phase lag Theory of Thermoelasticity by Rakhi Tiwari Department of Mathematics, Nitishwar mahavidyalaya, A Constituent Unit of Babasaheb Bhimrao Ambedkar Bihar University, Muzaffarpur rakhibhu2117@gmail.com

The propagation of magneto-thermoelastic waves generated by a thermal shock in a finitely conducting elastic half-space in contact with vacuum has been studied. Three phase lag theory of thermoelasticity has been applied to account for the interaction among the elastic, thermal and magnetic fields. The boundary of the domain is subjected to a normal load. Laplace transform technique on time is used to obtain the solutions. A detailed analytical as well as numerical study has been done using three phase lag theory of thermoelasticity. As Dual phase lag is a special case of Three phase lag model of thermoelasticity. In order to make a comparative study, computational results have been calculated graphically in both (Dual phase lag and Three phase lag thermoelasticity). We obtain significant differences in both the models. However in some places, Three phase lag model exhibits better results as compare to Dual phase lag model of thermoelasticity.

2. Blocking dynamics of flexural gravity waves in three-dimensions by Susam Boral, Trilochan Sahoo Dept. of Ocean Engineering and Naval Architecture IIT Kharagpur, India susamboral@gmail.com

Surface gravity waves interact with the large floating elastic structure to generate flexural gravity waves which are of significant importance for ocean space utilization as well as in the impingement of ocean waves with sea ice in the marginal ice zone. In the presence of current, blocking of one-dimensional flexural gravity waves and buckling of the flexible plate have been demonstrated for certain critical values of compressive force by analyzing the corresponding dispersion relation which possesses five roots in case of deep water. However, various limiting conditions such as threshold of blocking and the buckling limit are related to the occurrence of multiple roots of the flexural gravity wave dispersion relation which are otherwise distinct in nature. In the present study, blocking dynamics of two-dimensional flexural gravity waves is studied in the presence of current and compressive force in the three-dimensional fluid domain. The basic scenarios of wave blocking in the presence of top-hat current are analyzed as a special case. Further, between the blocking and buckling limit, for some fixed value of wave frequency, the wave dispersion relation possesses three real roots of which two roots coalesce either at the primary or secondary blocking points which is similar to the case of two-dimensional flow. The study reveals the occurrences of wave blocking for flexural gravity wave and buckling of the structure depend not only on the compression of the plate or current flow but also on the directions of wave propagation and current flow.

3. Viscosity variation and porous wall effects in conical squeeze film bearing using Rabinowitsch fluid lubricants by Amit Kumar Rahul Department of Mathematics & Computing Indian Institute of Technology(ISM) Dhanbad, India

akrahulism@gmail.com

In this research article, viscosity variation of a non-Newtonian fluid with porous conical bearing has been theoretically analyzed over the Rabinowitsch fluid index,  $0.00004 \leq \omega \leq 0.00002$  and viscosity index  $(0 - 1)$ . The porous matrix consists, a system of capillaries of very small radii with homogeneous porous wall. The modified Reynolds equation representing the non Newtonian properties following the cubic stress law condition is determined. An approximate analytical solution is found using a small perturbation method. The solution for pressure and load capacity with distinct values of viscosity-variation and porous parameter are calculated and compared with Newtonian lubricants. The results reveal that the effect of porous wall enhances the load-carrying capacity and lengthen time but the viscosity variation of non-Newtonian fluid decreases the load-carrying capacity and response time, as compare to the non-Newtonian lubricant.

4. Propagation of wave in two-layer Ocean over varying bottom in presence of porous walls by Nagmani Prasad, Ramanababu Kaligatla, Saista Tabssum Department of Mathematics & Computing Indian Institute of Technology (ISM) Dhanbad, India nagmani0609@gmail.com

In two layer fluid, a scattering problem of oblique wave by multiple porous walls in the presence of varying bottom is tackled. Here, the bottom profile is an association of an uneven bottom of finite interval and constant water depths of semi-infinite intervals in a way for step-type. The multiple porous walls are placed toward wind side of the constant water depth. In two layer fluid system, both the fluids of two different densities and finite depths are assumed while the fixed porous walls are extended up to the free surface. Using small amplitude water wave theory and Darcy's law over the fluid flow across the porous walls, The problem is modeled as BVP. To deal the solution of the current problem, method of matched eigenfunction and modified mild-slope equation (MSE) is applied. Further, the continuity conditions of the fluid pressure at the point of bottom slop discontinuities and mass flux at the interface is utilized to convert the boundary value problem into a system of equations. Further, the performance of the multiple porous walls as a breakwater to mitigating the wave energy, the reflection and transmission coefficients, wave forces on barriers are computed against parameters such as slope length, interface height, incident wave angle and porosity. The results are likely to be useful to assess the performance of porous walls as a breakwater in water of uneven depth.

5. Energy balance relations for flow through thick porous structure by Santanu Koley Department of Mathematics, Birla Institute of Technology & Science - Pilani Hyderabad Campus, Telangana, India santanukoley1989@gmail.com

In wave-structure interaction problems, energy balance relations often derived and used to check the computational accuracy of the numerical methods. These energy identities also used to get qualitative information about various physical quantities of interests. It is well known that for rigid structures, the energy identity is  $|R|^2 + |T|^2 = 1$ , where  $|R|$  and  $|T|$  are reflection and transmission coefficients respectively. Even if we take flexible barriers then also the aforementioned energy identity will hold. This gives us an useful information that no wave energy is used to deform the flexible barrier. Now, for porous structure, often a part of the incoming wave energy is dissipated by the structural porosity. So, the aforementioned energy identity will be modified into  $|R|^2 + |T|^2 + K_D = 1$ , where  $K_D$  takes into account the amount of dissipative wave energy. These energy identities are available in the literature for thin porous barriers. But, derivation of the energy identity is complicated for thick porous structures due to complex momentum equation and boundary conditions. In the present paper, an appropriate energy identity will be derived for water waves past a thick rectangular porous structure. In this regard, Green's second identity is used in multi-domain regions with the arguments velocity potential and its complex conjugate. With the help of complex function theory, the final form of the

same is the following:

$$|R|^2 + |T|^2 + K_D = 1$$

where

$$K_D = F \left( m, f, k_0, \theta, \omega, g, \phi_1(0, z), \frac{\partial \phi_1^*}{\partial x}(0, z), \phi_3(b, z), \frac{\partial \phi_3^*}{\partial x}(b, z), \phi_2(x, 0) \right)$$

In this aforementioned equation,  $m$  is the inertial coefficient,  $f$  is the friction coefficient,  $k_0$  is the progressive wave mode,  $\omega$  is the angular frequency,  $\phi_j$  for  $j = 1, 2, 3$  are the velocity potentials for the regions left, within and right to the porous structure and  $\phi^*$  is the complex conjugate. It is to be noted that the rectangular porous structure is having width  $b$  and situated between  $x = 0$  to  $x = b$  along the horizontal direction and  $z = 0$  to  $z = -h$  along the vertical direction. Now, to compute various quantities associated with the energy identity, the associated BVP is converted into a system of Integral equations using appropriate Green's function. The derivations of the free surface Green's function for porous region is complex and will be handled in a suitable manner. Finally, using quadrature formulae, the components present in the energy identity will be obtained and checked for validation.

6. Combined effects of periodic suction and permeability on MHD oscillatory flow of Rivlin Ericksen fluid past a moving semi-infinite porous plate in the presence of thermal radiation by Deepti Department of Mathematics, Shivaji College (University of Delhi), Raja Garden, New Delhi-110027 [deepti\\_math@yahoo.com](mailto:deepti_math@yahoo.com)

In this paper the behaviour of unsteady flow of viscous incompressible and electrically conducting Rivlin Ericksen fluid past a semi-infinite vertical porous plate having variable permeability under thermal radiation effects is examined. Further the time dependent suction is assumed at the plate which is moving with constant velocity whereas the free stream velocity is assumed to be oscillating with time. The dimensionless governing equations for the fluid flow under investigation are reduced to set of ordinary differential equations using two term harmonic and non-harmonic functions and solved analytically under relevant boundary conditions. Further the analytical results obtained for velocity, temperature and concentration profiles are evaluated numerically and their variation with different flow parameters are shown graphically. Also, the variation behaviour of Skin friction, Nusselt number and Schmidt number along with their amplitudes and phase angles for pertinent parameters is displayed graphically.

7. Transient MHD Casson Fluid Flow past an Inclined Surface by S. Talukdar Department of Mathematics Girijananda Chowdhury Institute of Management and Technology (GIMT)-Tezpur [talukdarsujit15@gmail.com](mailto:talukdarsujit15@gmail.com)

A transient MHD Casson fluid flow past an inclined moving plate is examined to address the effect of chemical reaction and thermal radiation. The resulting system of the equations governing the flow is solved analytically using regular perturbation technique. The numerical results obtained are presented graphically against the different values of the parameters entering into the problem and interpreted physically showing an excellent agreement with the physical reality of the problem

8 On Superintegrable Monopole Systems by Md Fazlul Hoque Department of Mathematics Pabna University of Science and Technology, Pabna - 6600, Bangladesh [fazlul\\_math@yahoo.co.in](mailto:fazlul_math@yahoo.co.in)

One important class of superintegrable monopole models is Kaluza-Klein monopoles and its complete algebraic description, which allows a dynamical symmetry of quantum motions. In fact models in space with Taub-NUT metric have attracted much attention and this metric is well known to admit the Kepler-type symmetry and provides nontrivial

generalization of the Kepler problems. In this talk, we overview new families of superintegrable Kepler, MIC-harmonic oscillator and deformed Kepler with Yang-Coulomb monopole systems in flat space and curved Taub-NUT space. We present their algebraically independent integrals of motion via direct and constructive approaches, which show the superintegrability of the models. The integrals form symmetry algebras of the corresponding Hamiltonians with structure constants involving Casimir operators of certain Lie algebras. Such algebra approaches provide a deeper understanding to the degeneracies of the energy spectra and the connection of the wave functions with differential equations and differential geometry.

### 9. Scattering of Surface Gravity Waves by a Porous Box by Sofia Singla Department of Mathematics, Indian Institute of Technology Ropar, India sofia.singla@iitrpr.ac.in

Scattering of oblique surface gravity waves by a surface-piercing porous box in the water of finite depth is investigated. The mathematical problem is based on the small-amplitude water wave theory and Darcy's law for flow past porous structure. Using the matched eigenfunction expansion method, the boundary value problem is reduced to a system of linear algebraic equations, which is solved numerically. The assessment of the mathematical model is made through a comparison with the existing experimental and theoretical studies. The efficiency of the proposed model in reflecting, transmitting and dissipating wave energy is demonstrated numerically. The study reveals that the height and width of the porous box play important roles for not only in trapping surface waves within the porous box but also dissipating a major part of wave energy by the structure. The study will provide useful information in the creation of a tranquility zone in ports, harbors, marina, bays and other marine facilities.

### 10. Energy Stability of Natural Convection in an Inclined Fluid Layer by Manisha Arora Centre for Advanced Study in Mathematics Panjab University Chandigarh, India arora12794@gmail.com

An energy stability analysis of convection in an inclined layer of a viscous, incompressible fluid is carried out. The nonlinear stability boundary for the underlying dynamical system is obtained in terms of control parameter Rayleigh number. It is observed that the nonlinear stability boundary depends upon the inclination of the layer with respect to the horizontal and the Prandtl number of the fluid. A comparison with the linear instability boundary for the considered hydrodynamic system indicates a possibility of subcritical region.

### 11. Wave propagation in elastic-plastic material with voids by Suraj Kumar Department of Mathematics Panjab University, Chandigarh - 160 014, India surajkumar1993@gmail.com

Constitutive relations and governing equations have been developed for an elastic-plastic material with voids having single slip-plane and direction. The plasticity of the material is considered through the dislocation of slip-plane. The propagation of uni-directional plane waves has been explored in an infinite elastic-plastic material with voids and found that there exist four basic waves consisting of three coupled elastic-plastic waves and a lone transverse wave. The speeds of propagation of all the coupled elastic-plastic waves are found to be affected by the plasticity and void parameters, in general, while the transverse wave is not affected by the plasticity and void parameters and travels with the speed of classical transverse wave. Out of the three coupled elastic-plastic waves, two waves are the counterpart of the waves existing in elastic material with voids, while the third wave is new and has appeared due to the presence of plasticity in the material. One of the coupled elastic-plastic waves that is least affected by the plasticity faces critical frequency, below which the wave is a non-propagating wave. This critical frequency arises due to the presence of voids in the medium. The speed of various waves are computed for a specific

model and results obtained are presented graphically. At large frequency values, all the coupled elastic-plastic waves propagate with constant speeds, but at low frequency values, they propagate with speeds less than that of the longitudinal wave of classical elasticity. Several earlier known results have been recovered as special cases from the present formulation.

12. Propagation of Rayleigh-type wave in a layered thermo-elastic medium with double porosity by Davinder Kumar Department of Mathematics Panjab University, Chandigarh - 160 014, India davinderkgoriwal@gmail.com

In this work, propagation of Rayleigh-type surface wave has been explored in a finite layer bonded over a half-space consisting of thermo-elastic medium with double porosity structure. Theory of thermo-elastic solid with double porosity structure given by Iesan and Quintanilla (2014) has been used for this study. The Secular equation has been derived analytically and is found to be dispersive and complex in nature. For a particular model, the secular equation is solved numerically. Dispersion of phase velocity, through-thickness displacements and stresses has been depicted graphically. Several special cases have been also deduced from present formulation.

13. Analysis of reflection and refraction of P-waves in an intermediate layer lying between two semi-infinite media by Pooja Singh Department of Applied Mathematics, Indian Institute of Technology (Indian School of Mines), Dhanbad - 826004, Jharkhand, India poojaismit@gmail.com

The present article undertakes the analysis of reflection and refraction of a plane wave at the interfaces of layered structured comprised of a water layer of finite thickness sandwiched between an upper half-space constituted of ice and a lower isotropic elastic half-space. A closed form expression of amplitude ratios of reflected and refracted waves has been derived in terms of angles of incidence, propagation vector, displacement vector and elastic constants of the media. Expressions corresponding to the energy partition of various reflected and refracted waves have also been established analytically. It has been remarkably shown that the law of conservation of energy holds good in the entire reflection and refraction phenomena for different angles of incidence. A numerical examples were performed so to graphically portray the analytical findings. Further the deduced results are validated with the pre-established classical results.

14. Analysis of Flexoelectricity on Surface Wave Transmission in Two Layered Piezo-Structure by Sonal Nirwal Department of Mathematics and Computing, Indian Institute of Technology (Indian School of Mines) Dhanbad 826004, Jharkhand, India sonal.iitism@gmail.com

In the present study, propagation of the surface wave in a two-layered structure composed of piezoelectric materials has been investigated. In the composed model, a piezoelectric plate is overlying on another piezoelectric plate with a perfect interface. Based on first-order shear deformation principal, flexoelectricity is considered in the upper piezoelectric layer and the governing equations are derived accordingly. In particular, composite piezoelectric plates are taken into account to sketch the dispersion curves (for both electrically open and short circuit cases). To obtain the dispersion relation, the mathematical formulation has been done and solved analytically. Variation of phase velocity versus wavenumber has been distinctly marked. The influence of the flexoelectric coefficient on the phase velocity curves (of first and second mode) has been shown graphically. This study may serve as a fundamental criterion to calibrate the 2-D theoretical model of the flexoelectric system.

15. **Mathematical Modeling of Hollow Fibre Membrane Bioreactor: An Application in Tissue Engineering** by Prakash Kumar Department of Mathematics Indian Institute of Technology Kharagpur, India kumarprakashji@gmail.com

Hydrodynamics and nutrient transport in a hollow fibre membrane bioreactor (HFMB) is studied by developing a 2D mathematical modelling in Cartesian coordinates. The HFMB consists an annular scaffold attached to the periphery along with a fibre membrane which separates the lumen with scaffold. The scaffold is elastic and deformable in nature which undergoes deformation with the applied pore pressure. The scaffold consists of stem cells attached to the porous matrix for proliferation. The cells are assumed to be strictly adhered to the scaffold matrix which allows us to consider both as a single solid phase in that region. The corresponding mixture equations are reduced and derived into the biphasic mixture model for the solid and fluid phases. Stokes and Darcy equations govern the incompressible fluid in the lumen and porous membrane. The method of lubrication theory is incorporated with approximation of small aspect ratio of the lumen. The nutrient transport in the scaffold region is assumed to be governed by advection-diffusion-reaction due to the presence of cells and advection-diffusion in the lumen and porous membrane. Analytical solution of the coupled system is presented while the results focus the effect of various parameters on the fluid flow and nutrient consumption by different kind of cells. The factors which affect the nutrient concentration are porosity and permeability of the scaffold, Thiele modulus, pressure gradient etc. The model helps to identify appropriate key physical parameter values to monitor the experiments in obtaining adequate nutrient supply in the bioreactor for better cell proliferation.

16. **Biphasic mixture model to an in-vitro tumor - existence and uniqueness results** by Meraj Alam Department of Mathematics Indian Institute of Technology Kharagpur, India merajalam113@gmail.com

In this work, we propose a mathematical model that describes poroelastohydrodynamics (interstitial hydrodynamics + the deformation of tissue material) within an isolated solid tumor. It is assumed that the tumor tissue region is deformable and behaves as a homogeneous porous medium. The theory of mixtures is adapted to write mass and momentum balance equations for poroelastohydrodynamics. The momentum balance equations are coupled via the interaction forces between the phases (fluid and solid). In general, the supply of fluids and macromolecules within a tumor is heterogeneous due to the heterogeneous blood vessel distribution. In order to take into account these features, the physiological transport parameters (e.g., hydraulic conductivity or permeability) are assumed as functions of space and dilatation. This assumption introduces nonlinearity in the governing model equations, which form a system of elliptic partial differential equations. Here in this article, we developed the well-posedness of governed model in a weak sense. In order to show the well-posedness, we require some basic mathematical tools such as Sobolev spaces, Poincare's, Holder's, Korn's and trace inequalities. We convert the system of PDEs into an equivalent variational formulation using Greens' Theorem. Further, we derive a priori estimate's on the solution and establish the existence of a weak solution using Galerkin and weak convergence methods. We further show the local uniqueness of the solution and continuous dependence on the given data.

17. **Effect of Heterogeneity and Porosity on Love Waves in a Heterogeneous Orthotropic Layer over a Gravitating Porous Half-Space** by Anup Saha Department of Mathematics, Rampurhat College Rampurhat, Birbhum, India sahaanup1989@gmail.com

The present paper is concerned with the propagation of Love waves in a heterogeneous orthotropic layer under changeable initial stress over a gravitating porous half-space. In the upper layer the heterogeneities in initial stress, density and shear moduli obey the laws  $P = P_0(1 + \sin\alpha z)$ ,  $\rho = \rho_0(1 + \sin\alpha z)$  and  $Q_i = a_i(1 + \sin\alpha z)$ . The dispersion equation of Love waves has been deducted in a closed form by means of the method of variable

separation. The study reveals that the presence of heterogeneity, initial stress, ratio of directional rigidities, gravity and porosity of the porous half-space approves the significant effect of these parameters in the propagation of Love waves. The velocity of Love waves has been computed for several cases. It has also been observed that for a homogeneous orthotropic layer over a homogeneous orthotropic half-space, the velocity equation obtained is in agreement with the corresponding result.

18. Unsteady MHD free convection in a radiating fluid flow past a vertically time-dependent moving plate with ramped double-diffusive condition by Harekrishna Mandal Department of Mathematics, Balurghat College, India kmathk@gmail.com

Unsteady MHD free convection and mass transfer from a viscous, incompressible, electrically conducting and chemically reacting fluid flow past a vertical infinite flat plate is investigated. The flow is induced by a general time-dependent movement of the vertical plate, the cases of ramped temperature and constant plates are studied. Exact solutions of the governing equations are obtained. The Sherwood number, Nusselt number and skin friction coefficients are obtained for both ramped temperature and isothermal plates. Applications of practical interest are discussed for different types of plate motions. The numerical values of species concentration, fluid temperature and fluid velocity are displayed graphically whereas the numerical values of Sherwood number, the Nusselt number and skin friction are presented with help of graph, for different parameter values for plate moving with (i) uniform velocity, (ii) uniform acceleration and (iii) periodic acceleration respectively for both ramped and constant plates. Solution for  $Pr = 1$  (electrolyte) and  $Sc = 1$  (methanol) are also obtained.

19. Analytical study of surface wave in porous piezoelectric composite structure by Juhi Baroi Department of Mathematics and Computing Indian Institute of Technology (ISM), Dhanbad - 826004 juhibaroi@gmail.com

An analytical solution for propagation of surface wave in a Porous Piezoelectric Material (PPM) layer lying over a Dielectric substrate is proposed with different interface conditions. Different boundary between the two media is considered e.g. perfect, imperfect etc. For the imperfection of the interface spring model in linear form is considered. The dispersion matrix is calculated for both, electrically open and short circuit cases. Numerical example and graphical representation have been made to illustrate the effect of different material properties on the velocity of surface wave. Finally, the outcome of present study is matched with classical Love wave result. Obtained solution may be utilized for theoretical optimization of structure of devices made of piezo-composites.

20. Mathematical Modeling of Contaminant Transport through Anisotropic Porous Soil Layers by Jagabandhu Dixit Dept. of Civil Engineering, Shiv Nadar University Gautam Buddha Nagar, Uttar Pradesh jagabandhu.dixit@snu.edu.in

The fate of contaminants in the soils and modelling the contaminant flow through an anisotropic heterogeneous porous soil medium is a challenge due to the scale of the problem and the complexity of the coupled equations involved in it. The increased concentration of the chemical content in the soil pollutes the ground water through percolation, its gets deposited in the plants and fruits through the process of evapotranspiration, and it causes deterioration in the steel reinforcement provided for underground structures leading to a reduction in life of the structure. This work aims to calculate the effects of the chemicals and the rate of deterioration based on a finite volume method. A cuboidal boundary is chosen for the simulation and a selected site is set as an inlet for contaminants to flow through all other sources of contaminants are neglected. A modified Navier-Stokes equation is used for computing porous flow and convection-diffusion equation is used for computing chemical transport of contaminants through the soil. Soil is a multiphase system that requires a model for simultaneous solution of flow of water and chemical. This



work considers soil medium to be fully saturated. The convection diffusion equation considered in this study is a coupled combination of diffusion and convection. Diffusion takes place due to intermingling of particles present in water and the convection take place due to motion of water along with the chemicals through the soil pores. The chemical concentration changes with the velocity of water and the flow through the soil medium has a net effect on mass balance. The final equation is derived by considering mass balance of the chemical species by setting net change of mass to be equal to mass entering. The mass fraction presented through the plots signifies the total amount of chemical infiltrating through the soil domain.

21. Thermoelastic modelling for the rectangular plate under the hyperbolic heat conduction theory in a differential transform domain by Kamini Pillai College of Engineering New Panvel, Navi Mumbai, Maharashtra (India), kaminc2012@gmail.com

In this paper, the differential transform method based on Taylor's series method is presented for solving hyperbolic heat conduction equation with an internal heat source, under thermoelastic media. The two-dimensional finite rectangular plate is considered and thermoelastic behaviour is studied for it. We determined the temperature distribution in the plate follows the non-Fourier heat conduction law and also simulate the thermal stress and displacement along spatial direction using stress function and displacement function. The effect of periodically varying heat source on stress components is also studied and depicted numerically and graphically for a special case.

22. Thermal stress intensity factor for an edge crack in orthotropic composite media by Anuwedita Singh Department of Mathematical Sciences Indian Institute of Technology(BHU) Varanasi, India anuweditavishen@gmail.com

The purpose of this article is to determine the thermal stress intensity factor (SIF) of an edge crack situated in an orthotropic strip of finite thickness  $h$  bonded to an orthotropic half plane, under thermal and mechanical loadings. The problem is reduced to a singular integral equation of the first kind. The integral equation is converted to a pair of the singular integral equations using asymptotic expansion method. The analytical expression of the stress intensity factor at the edge crack tip is found for concentrated point loading. The numerical values of SIF are computed for different point loading for various crack lengths and different ratios of thermal conductivities for different particular cases when the composite orthotropic material is the mixture of Steel-Myler and E-Glass epoxy. The significant feature of the article is the pictorial presentations of the variations of SIF due to the effect of ratios of thermal conductivities of both the materials.

23. Response of Integral Transform Technique in Thermal Stresses of Hollow Cylinder by means of Internal Moving Point Heat Source by Sangita B. Pimpare<sup>1</sup>, Chandrashekhar S. Sutar<sup>2</sup> <sup>1</sup>Department of Mathematics, G.T.Patil College, Nandurbar <sup>2</sup>Department of Mathematics, PSGVPMS's ASC College, Shahada, Dist.Nandurbar sangitamhjn@gmail.com

The present paper concern with the study of thermoelastic model in hollow cylinder. In this paper thermal stresses has been determined in hollow cylinder with internal moving point heat source. To find the solution of mathematical thermoelastic model the integral transform technique is used. The numerical results are also shown by considering the special case. The results are discussed by graphically.

24. MHD Poiseuille Flow of Viscoelastic Fluid in an Inclined Channel by Kiran Kumari Department of Mathematics, L B S PG College, Jaipur, India kiran.kumariprajapati@gmail.com

Heat and Mass transfer analysis for the MHD Poiseuille flow of viscoelastic fluid between two inclined plates through porous medium in the presence of radiation absorption, chemical reaction and thermal radiation is the subject of this investigation. Analytical solutions for velocity, temperature and concentration field are obtained by analytical method and the effects of flow parameters on resulting non-dimensional velocity, temperature and concentration are analyzed graphically.

25. Bending of a Rectangular Plate by Using Differential Transform Method by Chandrashekhara S. Sutar Department of Mathematics & Statistics PS-GVPM'S A.S.C. College, Shahada (M.S.) India sutarchandu@gmail.com

The present paper deals with the study of thermoelastic model in a rectangular plate. In this paper bending moment of a rectangular plate has been determined by the application of thermal stresses. The differential transform method is used to determine the solution of mathematical model. Also the results are discussed by graphically.

26. On the analysis of mixed convection in a rectangular vented cavity by Chitralkha Sarkar<sup>1</sup>, Swapan Kumar Pandit<sup>2</sup>, Durga Charan Dalal<sup>3</sup> <sup>1</sup>Department of Mathematics, Rampurhat College, Rampurhat, Birbhum - 731224, West Bengal, India <sup>2</sup>Integrated Science Education & Research Centre, Visva-Bharati, Santiniketan - 731235, India <sup>3</sup>Department of Mathematics, Indian Institute of Technology Guwahati, Guwahati - 781039, India chitralkha.math@gmail.com

A numerical investigation has been performed to study the mixed convection in a rectangular cavity where the bottom wall is considered to be wavy. The inlet is situated at the bottom part of one of the vertical wall and outlet is at the top portion of the opposite vertical wall. The modeled equations are two-dimensional(2D) Navier-Stokes(N-S) equations representing incompressible viscous flows. A colder fluid enters the enclosure through the inlet and a constant heat flux is applied at the above portion of the inlet at the vertical wall. Other walls are adiabatic. The relevant parameters are Reynolds number(Re) and Rayleigh number(Ra) which are also discussed in the present study.

27. Effects of relaxation and ion size on the electrophoresis of rigid colloid by Binod Kumara Parth<sup>1</sup>, P. Gopmandal<sup>2</sup>, R.K. Sinha<sup>1</sup> <sup>1</sup>Department of Mathematics, National Institute of Technology Patna, India <sup>2</sup>Department of Mathematics, National Institute of Technology Durgapur, India binod.math15@nitp.ac.in

Present work is a semi-analytical study on the electrophoresis of charged spherical rigid colloid by considering the effects of relaxation and ion size. The mathematical model is based on low Reynolds number for fluid flow in Stokes region. We adopt a linear perturbation technique under a weak electric field assumption. An iterative numerical technique is employed to solve the coupled set of perturbed equations. We have validated the numerically obtained electrophoretic mobility with the corresponding analytical solution derived under low potential limit. Going beyond the widely employed Debye-Hückel linearization, we have presented the results for a wide range of surface charge density, electrolyte concentration and slip length to Debye length ratio.

28. Elastic material with voids subjected to electro-magnetic interactions by Ashish Kumar Department of Mathematics Panjab University Chandigarh, India ashishkumarpu@gmail.com

The possibility of time harmonic plane waves have been explored in an elastic medium with voids subjected to large uniform static magnetic and electric field. The influence of electro-magnetic field is observed on the propagating waves. For different electric conductive materials, the speed of various waves is investigated under limiting cases of frequency. The phase speeds and corresponding attenuations against frequency are computed and

depicted graphically for a specific material.

## Section M : Bio-Mathematics

### 1. Double Allee effect in IGP systems and its Implications to Biological Control: A Theoretical Perspective by M.S. Bhuvanewari<sup>1</sup>, B.S.R.V. Prasad<sup>2</sup>

<sup>1</sup>Department of Mathematics, Vellore Institute of Technology, Vellore, India <sup>2</sup>Vellore Institute of Technology, Vellore, India bhuvanewari.sai1991@gmail.com

Intraguild predation (IGP) is a ubiquitous phenomenon in nature and differs from classical competition and predation. IGP is a particular case of food web dynamics, in which two or more taxa interact with each other with interactions ranging from competition for a shared resource to predation upon each other. Theoretical studies carried out on IGP predicts that the coexistence of intraguild predator and intraguild prey is only possible under certain restrictive assumptions. However, the results of empirical studies on IGP reveals a conflicting view from the theoretical predictions. Due to these discrepancies, ecologists are more fascinated with studying the dynamics of IGP by incorporating more realistic ecological factors. Allee effect is one of such exciting factors. The positive density-dependence of species for its survival is called the Allee effect, and it can manifest either in the birth, or mortality rate of species. In this article, we explore the effects of double Allee effect on the dynamics of IGP system by formulating a simple mathematical model. In doing so, we have considered both the strong and weak Allee effect separately. We probed into the conditions for predator and prey to exclude each other and also for conditions of coexistence. The local bifurcation analysis (transcritical, Hopf) and global bifurcation analysis (viz., saddle-node, homoclinic and Bogdanov-Takens) have been carried out by considering the intrinsic growth rate of predator and predation rate of the predator on prey as bifurcation parameters. Numerical simulations are performed to validate the analytical findings. The findings of the present study highlight the role of the Allee effect in IGP systems and its outcome on the biological control programs.

### 2. KCC Theory and its Application to Time Delay Spatio-Temporal Prey-Predator Model by T.N. Mishra DST-Centre for Interdisciplinary Mathematical Sciences, BHU t.mishra01@gmail.com

The KCC theory is based on the assumption that the second-order dynamical system and geodesics equation, in associated Finsler space, are topologically equivalent. In this work, time delay spatio-temporal prey-predator model has been taken as an application and the studied the stability of it by using KCC theory. Both linear and Jacobi stability of the model have been discussed in details. Further, the effect of time delay parameter on stability of model has been observed and measured the presence of chaos in the model. The bifurcation and critical value of bifurcation parameter have been investigated. The numerical examples of particular interest have been taken to compare the results of Jacobi stability and linear stability. It is observed that Jacobi stability on the basis of KCC theory is global than the linear stability.

### 3. Mixture theory based tumor growth and development in gel-like tissues by Bibaswan Dey Department of Mathematics, University of North Bengal Raja Rammohunpur campus, Darjeeling-734013, India bibaswandey@nbu.ac.in

In the present investigation, an in-vivo mimicking model of two-phase avascular tumor growth is presented. The tumor is assumed as a two-phase mixture of tumor cells and extracellular fluid. We consider tumor cells to behave as viscous liquid having viscosity different from the extracellular fluid. The tumor is allowed to grow within an ambient two-phase medium which is characterized by 3:2 proportion of viscous hydrogel and small proportion of normal cells. The present model focuses on the mechanical interaction between the growing tumor and the surrounding hydrogel medium that influences the growth dynamics. The stress induced into the surrounding hydrogel medium as a result of

radial expansion of tumor spheroid has been described through mass conservation and force balance equations for each phase inside both the regions and stresses are balanced at the tumor-hydrogel interface. The growth is mainly mediated through the externally supplied nutrients and oxygen inside the hydrogel medium. Entire poroelastohydrodynamics is coupled with mass transport model for nutrient and oxygen transport inside the tumor spheroid.

We employ semi analytical techniques to solve the governing poroelastohydrodynamic and mass transfer equations. The obtained results demonstrate useful insights on the growth process e.g., onset of necrosis inside the tumor, impact of surrounding medium on the dynamics of tumor growth as well as classifying scenarios of assisting and delaying necrosis. Significant parameters controlling the dynamics are metabolism rate of tumor cells, nutrient diffusivity, hydraulic conductivity, nutrient supply from the surroundings etc. Two stages are considered here corresponding to development of the tumor: (i) initial stage when there is no necrosis (ii) advanced stage post necrosis. Computed theoretical results are compared with existing theoretical and experimental data in literature to validate the model developed.

**4. Math Modeling and Drug Diagnosis of Salmonella** by Surendiran S. Department of Mathematics with Computer Applications PSG College Of Arts And Science, Coimbatore, Tamilnadu, India ssurendiran1999ps@gmail.com

In this work we will look at the SIR model for Mathematical Modelling of Salmonella disease. Mathematical models allow us to extrapolate from current information about the state and progress of an outbreak to predict the future and, most importantly to quantify the uncertainty in these predictions. Salmonella occurs worldwide (except the poles of earth), urban and rural areas, developed and developing countries. It can be transmitted by humans through direct and indirect ways. The transmission of disease is studied through mathematical model. Numerical solutions are shown support the theoretical problems.

**5. Dynamics of Cholera Transmission Model with Limited Medical Resources** by Vijay Pal Bajjiya, Jai Prakash Tripathi Department of Mathematics Central University of Rajasthan, Ajmer, India bajjiya123@gmail.com

In this work, we proposed a mathematical model for the transmission of cholera disease incorporating limited medical resources. The treatment function in model, is assumed to be a continuous and differentiable function of infected individuals which captures the effect of deferred treatment due to limited medical resources and the number of infected individuals is large enough. The global dynamics of model investigated and then we try to understand the effects of capacity of the treatment. It is found that backward bifurcation also occurs. Therefore, decreasing of the basic reproduction number less than unity is not enough condition to eradication of the disease and critical value at the turning point is assumed as a new threshold to eradication of the disease. Some enough conditions to disease free equilibrium and endemic equilibrium being asymptotically stable are also investigated. Mathematical findings of this work suggest that we should improve medical technology and increase medical resources to give the patients timely treatment.

**6. A two species Amensalism model with Allee effect on first species and harvesting on second species** by Sarita Bugalia, Jai Prakash Tripathi Department of Mathematics Central University of Rajasthan, India, saritabugalia44@gmail.com

In this work, we proposed a two species Amensalism model with Allee effect on first species and harvesting in second species. The interaction between species is of Amensalism type with Holling type II functional response. We show the local stability of all equilibria are under certain conditions. We analyzed the effect of Allee parameter and harvesting. Further, we analyze qualitative and bifurcation analysis of the system. We also observe that

Allee parameter can generate and destroy the interior equilibrium. Further we demonstrate that the system is bistable. In numerical simulation we see the behavior of the system with and without Allee effect. Allee effect influence only first species. Because of Allee effect the system takes longer time to reach its stable steady state solution and decrease the final density of species. The role of harvesting in the model is also analyzed.

7. **Mathematical Modeling of Glucose-Insulin-Glucagon model using ingested glucose and somatostatin** by Aditya Ghosh Department of Mathematics, Adamas University, Kolkata, West Bengal, India ghosh.aditya.iitg08@gmail.com

This paper is focusing on an interactive Glucose-Insulin-Glucagon model in the presence of externally ingested glucose which has logistic type growth. This model is inspired from the model of Centre for Human Drug research (CHDR). This model also taken into account the internalization of glucose receptors. In this work somatostatin has been implemented and its' effect has been analyzed mathematically and numerically. We have used somatostatin as on-off function. We consider this model into three different time periods. Optimal control policy has been used in different time phases. Pontryagin's principle is used here to determine it.

8. **Effect of information and treatment in an SEIR model** by Tanuja Das Department of Mathematics, Indian Institute of Technology Patna, India tanujamanidas@gmail.com

In this work, we study a susceptible-exposed-infective-recovered (SEIR) model with a nonlinear incidence function and saturated treatment function. This incidence function accounts for the sensitivity of susceptible individuals towards the infective density in population due to the impact of media coverage. We analyse the model for stability. We obtained the basic reproduction number  $R_0$  for the model. It is shown that when  $R_0 < 1$ , the disease dies out and the disease free equilibrium is globally stable. When  $R_0 > 1$ , the disease free equilibrium becomes unstable and there is possibility of existence of three endemic equilibrium points. Stability of endemic equilibrium is performed analytically when it is unique and it is shown globally asymptotically stable conditionally. Numerically we have shown the existence and stability properties in case of multiple endemic equilibrium. Also, numerical simulations are used to explore and analyse our analogical findings. We observe that saturation in treatment and information plays important role in the dynamics of disease spread.

9. **Modeling the Impact of Information, Vaccination and Saturated Treatment on Infectious Diseases** by Anuj Kumar School of Mathematics, Thapar Institute of Engineering & Technology, Patiala, India anujdubey17@gmail.com

The present study focuses to explore the dynamics of infectious diseases via proposing and analyzing a nonlinear compartmental model. The model accounts for the effect of information on vaccination coverage (i.e. information-induced vaccination) on healthy population and saturated treatment policy on the infective population due to the limited medical resources. Model analysis is performed and the global stability of the disease free equilibrium is established when treatment is available sufficiently. Multiple endemic equilibrium points are found due to saturation effect considered in medical treatment and information-induced vaccination. Under a parametric condition, the global asymptotic stability of the unique endemic equilibrium is established. Furthermore, the existence Hopf bifurcation is shown analytically when medical resources are limited which infers the oscillatory persistence of the disease within the population. Occurrence of Hopf-Hopf bifurcation is also investigated numerically. Hence, multiple stability switches are observed due to saturated form of treatment and information-induced vaccination. Our study infers that the model system gives rise to the rich and complex dynamics.

10. How the Transpiration through agricultural crops affects rainfall: a Mathematical model by Amita Tripathi Department of Mathematics, Banaras Hindu University, Varanasi 221005 India amita4utripathi@gmail.com

India is known as agriculture based country and agricultural crops in several regions depend on rainfall. During last few decades a less rainfall is observed in these regions and it is noted that atmospheric environment in these regions is deficient in humidity (water vapours). This leads to less rainfall in these regions. The water vapours in the atmosphere are mainly formed through the vaporization of water from oceans and they are also formed from agricultural crops through the transpiration process. In the present study, our aim is to formulate a mathematical model to see the effect of transpiration from agricultural crops on rainfall. In the formulation of model, it is assumed that water vapours are formed in the atmosphere through the transpiration of agricultural crops proportional to the crops apart from the oceans and other sources (assumed constant). In the presence of water vapours, cloud seeding techniques (use of conducive aerosols) are used to stimulate rainfall, which increases the agricultural crops with saturated type functional form. To capture the impact of environmental fluctuations, the stochastic version of the proposed model is also studied. The stability theory of ordinary and stochastic differential equations is used to predict the long term behaviour of the proposed model system. The analysis of model reveals that cloud seeding not only increases the rainfall but it also increases the agricultural crops and water vapours in the atmospheric environment. The analytical findings are well supported through numerical simulation.

## Section N : History and Teaching of Mathematics

1. Correction in the rule of Aryabhata during the case of differences between two Projections of Consecutive arc divisions by D.N. Garain<sup>1</sup> and Sanjeev Kumar<sup>2</sup> <sup>1</sup> Department of Mathematics, S.K.M. University, Dumka, Jharkhand, India <sup>2</sup>S.K.M. University, Dumka, Jharkhand, India sanjeev.aryu@gmail.com

In the present study we have modified the value of differences between two projections of consecutive arc divisions mentioned in the work of A. A. KrishnaswamiAyyangar entitled The Mathematics of Aryabhata. With the help of circumference-diameter ratio of Aryabhata, we have obtained two more corrected values. Also we have obtained the result with modern circumference-diameter ratio. We have found error percentage in three cases 0.14338558%, 0.000467054% and 0.14291853% respectively.

2. Teaching STEMM in 21st Century-A New Approach by Chanchal Dass Dass Scientific Research Labs Private Limited, Ahmedabad, India cdass01@gmail.com

Present work reports an innovative teaching technique of STEMM subjects using mathematics of transformations. Teaching Science, Technology, Engineering, Mathematics, and Medicine (STEMM) remained a challenge for centuries. It has become more challenging in the twenty-first century due to the rapid advancement of technologies. With the rapid advancement of technologies, STEMM subjects are developing at an accelerated rate. Day by day newer topics are being added up and the old topics are getting a substantial facelift. But the teaching methodology of these subjects remained stagnant for centuries. This is creating a huge gap between the required skill set and the actual skill set of students. Majority of the students struggling to keep pace with the new developments. In this scenario, teaching STEMM subjects in conventional way is not only making STEMM learning difficult, but it also creating a gap between desired skill set to actual skill set among the students globally. This has multifaceted negative impact on contemporary society and future generations to come. To overcome this problem, an innovative STEMM teaching methodology has been developed. The core of this innovation is few simple techniques that can convert any mathematical or scientific concepts into geometrical shapes without any coding or programming knowledge. On one hand, it reduces the abstractness of mathematical concepts, on the other hand, it provides clear understanding of the concepts. In

this paper, an attempt has been made to explain the objective, philosophy, methodology, and goal of the new STEMM teaching technique and how it can be effectively used in supplementing conventional teaching methodologies.

## Call for Applications for Various Awards to be given by the IMS for the Year 2019

Applications are requested from researchers in mathematics for the following AWARDS to be given by the Indian Mathematical Society for the year 2019. The last date for receiving the applications is June 30, 2019. The applications should be sent to Prof. Satya Deo, the General Secretary of the IMS, along with the copy of the published paper and the proof of the age on his e-mail address : sdeo94@gmail.com. Papers published in paid journals will not be considered.

### (1) A. K. Agarwal Award for the year 2019

Terms and Conditions for the Award:

- (a) The paper should be in the area of Number theory, Combinatorics, Discrete mathematics, Analysis and Algebra.
- (b) The paper should be in single authorship. In exceptional cases, the paper by two authors could be considered. In this event the prize amount will be equally divided (between the two authors). The author(s) should not submit more than one publication for this award.
- (c) The upper age limit is 45 years as on 31st December 2019. In case of two authors both must be below 45 years.
- (d) The papers considered must have been published either online or in print version during the year 2019. The paper must have been published in an internationally refereed journal. More weight age could be given to well established journals.
- (e) The author(s) should be Indian citizen and must have carried out the said research work in India.
- (f) The prize carries a certificate and a cash amount up to Rs. 10,000/- depending on the rate of interest on the accrued amount.

### (2) A. M. Mathai Award for 2019 (for best publication in Applicable Mathematics).

Terms and Conditions for the Award :

- (a) The paper should contain significant original contribution in any branch of mathematics which has some applications in other fields such as Physical Sciences, Biological and Medical Sciences, Social Sciences, Probability and Statistics.
- (b) The paper should be a single-author paper.
- (c) The upper age limit is 35 years as on December 31, 2019.
- (d) The author should not submit more than one publication for this award.
- (e) The papers must have been published either online or in print version during the year 2019. The paper must have been published in an internationally refereed journal. More weightage could be given to well established journals. The papers on routine generalizations, computations of formulae without proper analysis should not be considered for this award.
- (f) The author should be associated with any university/college/ institution in India where the work was done and the paper must have a mention of the name of that institution as affiliation (the person need not be an Indian citizen).
- (g) The paper sent for this award should not have been submitted or rejected for any other award.
- (h) The award carries a certificate and cash amount up to Rs 30,000/- depending on the rate of interest on the accrued amount.



(3) **Prof. Satish C. Bhatnagar Award for 2019** (For best paper in the area of History of Mathematics)

Terms and Conditions for the Award:

- (a) The paper must be in the area of History of Mathematics focusing on a person, problems, region, system of education or government.
- (b) The paper should be in single authorship. In exceptional cases, the paper by two authors is considered. In this event, the prize amount will be equally divided.
- (c) The minimum age limit for this award is 35 years as on 31st December 2019. There are no limits on the citizenship of the applicant. The award consists of a citation and a cash prize of Rs. 10,000/-.

Nominations for this award will also be considered.

**Prof. Satya Deo, General Secretary, IMS.**

**Prof. S. S. Shrikhande passed away**

Prof. S. S. Shrikhande, who is known for his breakthrough work (jointly with R. C. Bose and E.T. Parker) of disproof of the famous conjecture made by Euler that “there do not exist two mutually orthogonal latin squares of order  $4n + 2$  for any  $n$ ”, is no more. Prof. Shrikhande passed away on April 21, 2020 at the age 102. He was a life member of the IMS. May the departed soul rest in peace. The Indian Mathematical Society offers its heart fails condolences to the bereaved family.

## INDIAN MATHEMATICAL SOCIETY

**Council Members : 1<sup>st</sup> April, 2020 to 31<sup>st</sup> March, 2021**

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|---|--|
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| <p>3) Prof. Satya Deo,<br/><b>General Secretary</b>,<br/>HRI, Chhatnag Road, Jhusi,<br/>Allahabad - 211 019 (UP), India.<br/>vcsdeo@yahoo.com</p>               | <p>4) Prof. B. N. Waphare,<br/><b>Administrative Secretary</b><br/>Department of Mathematics,<br/>Savitribai Phule Pune University,<br/>Pune 411 007 (MS), India.<br/>waphare@yahoo.com</p>  |
| <p>5) Prof. Peeyush Chandra<br/><b>Academic Secretary</b>,<br/>Professor (Retired)<br/>Department of Mathematics<br/>IIT, Kanpur<br/>acadsecims@gmail.com</p>   | <p>6) Prof. S. K. Nimbhorkar<br/><b>Treasurer</b><br/>c/o Dr. Mrs. Prachi Kulkarni,<br/>Ankur Hospital, Tilaknagar,<br/>Aurangabad 431001, India.<br/>sknimbhorkar@gmail.com</p>             |
| <p>7) Prof. Sudhir Ghorpade<br/><b>Editor, J. Indian Math. Soc.</b><br/>Department of Mathematics<br/>IIT, Mumbai<br/>srg@math.iitb.ac.in</p>                   | <p>8) Prof. M. M. Shikare<br/><b>Editor, The Math. Student</b><br/>Department of Mathematics,<br/>Savitribai Phule Pune University<br/>Pune 411 007 (MS), India.<br/>mmshikare@gmail.com</p> |
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| <p>11) Prof. G. P. Youvaraj<br/>Ramanujan Institute,<br/>Uni. of Madras, Chennai-600 005,<br/>T. N., India</p>  | <p>12) Prof N. D. Baruah<br/>Dept. of Mathematical Sciences,<br/>Tezpur University,<br/>Assam, India</p>   |
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