Sabbatical Leave Application

Name Dan Roberts

Department or School Math

Year of Appointment 2012 Tenure Granted in / Contract Renewed in 2019

Total Number of Leaves Granted 1 Year of Last Leave spring 2020
(A report on the last leave must be filed in the Thorpe Center before you can apply again.)

Title of Sabbatical Project Applying the discharging method to integer-magic and integer-antimagic labelings of graphs

Request is for (please check one and fill in the year)

_____Full Year _____ Fall _X_ Spring of Academic Year 2027 _____

If your proposal is awarded, would you be willing for the Thorpe Center to use it as an exemplary submission in the online *Handbook*? _X_Yes ___No

Would you like to be considered for the Gardner Faculty Scholars Award? _X_Yes ___No

Please complete the following checklist by placing a check mark against each item to ensure that your application is complete. Incomplete applications will be returned to the applicant without further consideration. Please submit items 1-6 in one combined PDF.

X 1. Sabbatical Application Cover Sheet
X 2. Summary of the Project (≤150 words)
X 3. Supervisor's letter
X 4. Narrative (≤2,500 words)
5. IRB approval notice or veri ication that approval has been requested
X 6. Curriculum Vitae
X 7. Report of previous Sabbatical or Junior Faculty/Pre-Tenure Leaves, if any (File separately with the Thorpe Center)
X 8. A separate electronic summary (email Word copy to fdc@iwu.edu)

Please Note: All applicants should notify any relevant interdisciplinary programs of their pending sabbatical application and indicate the courses that will not be offered by the applicant during the sabbatical leave.

Signature  Date 10/30/25

Sabbatical Leave Proposal for spring 2027
Dan Roberts
Submitted fall 2025

Title: Applying the discharging method to integer-magic and integer-antimagic labelings of graphs

Summary
The discharging method is a powerful proof technique that has been used in graph theory for over 100 years. However, this technique has never been applied to integer-magic or integer-antimagic graph labelings. The goal of this project is to study the effectiveness of using the discharging method to prove the existence of integer-magic and integer-antimagic graph labelings. In particular, this work will allow us to make progress towards proving the main conjecture in the study of integer-antimagic labelings. Researchers in this area, including myself, have been making incremental progress towards proving this conjecture since it was stated in 2016. The results will be published in a peer-reviewed journal and presented at professional conferences.

Narrative
Introduction
Graph decompositions and graph labelings are my two primary areas of research. This project falls within graph labelings. My team and I have been working in this area for approximately 10 years, with progress largely occurring in small increments. While this progress has been very satisfying, and I assume typical of most research programs, it is also productive to make an occasional "giant leap." During my last sabbatical in 2020, we were able to achieve one of these giant leaps by successfully applying an old technique (called the combinatorial nullstellensatz) to our problem in a new way. This current sabbatical proposal will lay out how I plan for this to happen again, but with a different technique called the discharging method.

The discharging method is complex and learning it will require a sustained period of intense focus. After learning the method, it will need to be applied to our specific problems in graph labelings. This will likely be the most difficult part of the project. It requires creativity to fit the general method to the specific requirements of the problems under consideration. It is also the part where collaboration can be highly effective.

This leave will provide me the time to focus on learning the discharge method, applying it to specific research problems, and writing the results as a manuscript to send for peer review. It will also enable me to meet in-person with my collaborators, Richard Low from California and Ugur Odabasi from Turkey, for an extended period of time, which is critical for mathematical research.

A feasible staffing plan has been developed with the Math department for covering my teaching load. We will propose a VAP position. The backup plan is hiring adjuncts and absorbing some of my students into other courses. The details can be found in my supervisor letter.

Objectives

The objectives are the following:

- To learn how to use the discharging method, broadly speaking
- To apply the discharging method to the integer-magic and integer-antimagic problems
- To write and submit at least one article to a peer-reviewed journal
- To present the results at one or more conferences[1]

A leave is particularly useful for achieving the first two objectives. Learning the discharging method and applying it to group-magic and group-antimagic labelings will require a sustained and focused effort. This is not possible while carrying out the standard workload of a semester. Furthermore, mathematical collaboration is much more efficient and effective when done in person. To this end, my two collaborators and I plan to meet in one place for at least two weeks. Richard Low is from San Jose State University, and Ugur Odabasi is from Istanbul University. We will meet in either San Jose or Istanbul, depending on how our funding requests pan out over the next few months. If awarded this sabbatical, I plan to submit an ASD grant application, as well as apply for a Fellowship for Visiting Scientists[2] from Tubitak[3], as part of Turkey's national technology initiative.

Question to be studied

A graph is a mathematical object that consists of vertices and edges. Vertices can be viewed as dots, and edges are lines connecting the dots. One example of a graph is the internet: each website is a vertex and two vertices are connected by an edge if their corresponding websites are connected via a hyperlink. A labeling of a graph is an assignment of numbers to each of the edges.

Now, we must decide the possibilities for our choices of edge labels. For this we use a mathematical object called the group of integers modulo n, which is denoted Z_n. This is the set of integers from 0 through n-1 together with addition, together with the rule that you start over at 0 once you reach n-1. For example, to visualize Z_7 picture the numbers 0, 1, 2, 3, 4, 5, and 6 placed around a clock. Addition is computed clock-wise, where you must reset upon reaching 0. Thus, we get equations modulo 7 such as 2+5=0, 2+4=6, and 5+4=2. The set of numbers in Z_n is the one we use to label the edges of the graph.

There are many ways to label the edges of a graph. Once the edges of a graph are labeled, one can consider an induced labeling on the vertices. At each vertex, we take the sum of the labels on the edges attached to that vertex. In Figure 1, the edges are labeled by the black integers, and the induced vertex labels are shown in red. For example, the vertex with red label 5 has

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[1] One possibility is the 59th Southeastern Conference on Combinatorics, Graph Theory, and Computing

[2] https://tubitak.gov.tr/en/scholarships/postdoctoral/research-scholarship-programs/2221-fellowships-visiting-scientists-and-scientists-sabbatical-leave

[3] Tubitak is the Scientific and Technological Research Council of Turkey, much like the NSF in the US

been calculated by adding all of the attached black edge labels, then reducing modulo 7, i.e. 2+2+4+4=5 modulo 7. An edge labeling is said to have the antimagic property if all the induced vertex labels are different.

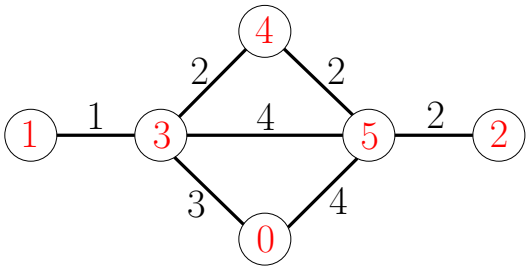

Figure 1: The black numbers comprise a Z_7-antimagic labeling of this graph. The red numbers are the vertex sums, which are considered modulo 7.

We allow for the edges of a graph to be labeled with non-zero elements of the set Z_n, with repeats allowed. After the edges are labeled, we compute the induced vertex sums. If all of these vertex sums are distinct, then the edge labeling is called a Z_n-antimagic labeling of the graph. For a given graph, if such a labeling exists, then we say that the graph admits a Z_n-antimagic labeling. The set of all values of n for which a graph admits a Z_n-antimagic labeling is called the integer-antimagic spectrum for that graph.

The main problem that we study is to characterize the integer-antimagic spectrum of each graph. In other words, given a graph, we would like to find all of the values of n for which that graph admits a Z_n-antimagic labeling. Furthermore, for each connected graph the smallest possible value of n is known (found by other authors). Since we know the smallest value of n that is in the integer-antimagic spectrum, the conjecture is that all values beyond this point are also in the integer-antimagic spectrum. Proving this conjecture is the holy grail of this area of research.

Methodology

Early work on this problem focused on systematically characterizing the integer-antimagic spectrum for many classes of graphs. Nearly all of this work was done by developing algorithms for each specific class of graphs. This is considered an ad hoc technique, since each algorithm would only apply to a specific type of graph. Therefore, the problem would need to be solved again and again, for each graph of interest to the researcher.

The first time a general method was applied to the integer-magic or integer-antimagic problems was when Richard Low and I used the combinatorial nullstellensatz to show the existence of group-magic labelings [Low and Roberts]. This work was a result of my last sabbatical in 2020. The technique consists of encoding a labeling of the edges of a graph as a polynomial. Then applying the combinatorial nullstellensatz to that polynomial by showing that it meets the required conditions. As a result of this application, the existence of an integer-magic labeling is guaranteed. As a side note, this was the first instance of being able to show that integer-magic

labelings exist without explicitly constructing such a labeling, i.e. we know they exist, but we have no idea what they look like.

The methodology of the proposed project is very similar to what was used in 2020 with the combinatorial nullstellensatz. The overall process is to study the general technique, apply that technique to our problem, and draw conclusions. There are two substantial differences: (1) our general method is now the discharging method as opposed to the combinatorial nullstellensatz, and (2) the discharging method can be applied to both integer-magic and integer-antimagic labelings as opposed to only integer-magic.

Significance to the scholarly community

Graph labeling has grown tremendously as an area of study since it was formally introduced in the 1960s. A dynamic survey of the field is updated and published every 1-2 years [Gallian]. The most recent edition in 2024 was 712 pages long and contained 3772 references. Catalogs of the results from both integer-magic and integer-antimagic labelings are included in their own sections [Gallian p.210]. This shows that there is interest in the scholarly community to investigate these types of labelings.

Moreover, one of the world's top graph theorists[4] recently pushed for researchers to find more applications of the discharging method. As part of this campaign, he and a collaborator published a paper demonstrating how to use the discharging method by applying it to graph coloring problems [Cranston and West]. A successful application of this method to the integer-magic and integer-antimagic problems will be mutually beneficial for researchers who study graph labelings, as well as advocates for the discharging method.

Importance to personal and professional development as a teacher and scholar

This project will add to my repertoire of techniques that can be used to tackle other problems in my research. The discharging method is a general technique that can be applied to many problems in graph theory, not just to integer-magic and integer-antimagic labelings. Learning about it could help me expand my research into other areas in the future.

Furthermore, solving the integer-antimagic problem is one of my main areas of focus. The results of this project have the potential to produce such a solution. That would be wonderful.

I incorporate my research into many of my courses. In particular, the two upper-level math courses Math 310 Combinatorics and Graph Theory and Math 412 Combinatorial Designs contain research projects for students. Adding the discharging method to my sphere of knowledge will unlock many more options for my students. This will also be true for independent research projects. I typically supervise about two of those per year.

[4] Douglas West, Professor Emeritus UIUC, Distinguished Professor Zhejiang Normal University

Summary of previous IWU-funded grants and leaves
Below are summaries and end products of my ASD and CD grants, as well as my prior sabbatical leave.

- Sabbatical leave spring 2020. Three articles published in peer-reviewed journals. Successful visit to San Jose State University to work with Richard Low on integer-antimagic labelings. We also began work on integer-magic labelings.
- ASD February 2023, award $3,500: Integer-magic labelings of maximal outer planar graphs. One article was published in a peer-reviewed journal.
- ASD February 2022, award $2,000: Furthering our understanding of how to use the combinatorial nullstellensatz to construct graph labelings. This grant was successful. End product: two articles published in peer-reviewed journals.
- ASD October 2019, award $3,500: The construction of integer-antimagic labelings of graphs. This grant successfully supported sabbatical travel during the spring 2020 semester (just before the pandemic). End products: three articles published in peer-reviewed journals.
- ASD Spring 2019, award $3,500: Searching for hypergraph designs. One article was published in a peer-reviewed journal. An IWU student was a co-author, and was supported through this grant for summer research. That same student co-authored another article that was published in a peer-reviewed journal as a result of that summer collaboration with a group of researchers at an REU.
- ASD Spring 2017, award $3,500: Optimally packing stars into complete graphs. A student and I participated in an REU over summer 2017. As a result I published three articles in peer-reviewed journals, and the student published one.
- CD Dan Roberts October 2023, award $2,000.00: Developing the new course Math 142 Calculation and Statistical Methods for Healthcare. Outcome: The new course was created and I've offered it five times since spring 2024. The math department will offer two sections per year in perpetuity, as it is now required for the Nursing major.
- CD Zahia Drici and Dan Roberts Spring 2022, award $4,000.00: Restructuring the math curriculum. Outcomes: Reorganizing and adding content in the math immersion sequence, shifting content within the calculus sequence, submission of a CC proposal for a new course Math 142 Calculation and Statistical Methods for Healthcare. The revised math immersion courses and Math 142 are all regularly offered as parts of the Math and Nursing curricula.
- CD Zahia Drici and Dan Roberts Spring 2019, award $5,000.00: Developing curricular components for the math first-year experience. Outcomes: These curricular components were used in teaching Gateway during Fall 2020, 2021, and 2022 (2 sections). Additionally, MATH 400 was taught Fall 2020 as a course cluster with the aforementioned Gateway and an Environmental Studies course. While the first-year experience no longer exists at IWU, Gateway is now part of the regular offerings from the math department.

References

Cranston, Daniel and West, Douglas. An introduction to the discharging method via graph coloring, *Discrete Mathematics* 340, 4, 2017, pp. 766 – 793.

Gallian, Joe. A Dynamic Survey of Graph Labeling, *Electronic Journal of Combinatorics*, #DS6, 2024.

Low, Richard and Roberts, Dan. Application of the combinatorial nullstellensatz to integer-magic graph labelings, *Theory and Applications of Graphs* 9, 2022, no.1, Art. 3.

Dan Roberts

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1312 Park St.
Bloomington, IL 61701

EDUCATION:

PhD in Mathematics
Auburn University, August, 2012.
Advisor: Dean Hoffman. Title of dissertation: Stars and Hyperstars.

Masters in Applied Mathematics
Auburn University, December, 2009.
Advisor: Dean Hoffman.

BS in Mathematics (cum laude)
University of Dayton, minor in philosophy, June, 2007.

EXPERIENCE

Professor, Illinois Wesleyan University (2023-present):

Associate Professor, Illinois Wesleyan University (2019-2023):

Assistant Professor, Illinois Wesleyan University (2013-2019)

Instructional Assistant Professor, Illinois State University (2020-present):

Visiting Assistant Professor, Illinois Wesleyan University (2012-2013)

Instructor of Record (Graduate Student), Auburn University (2008-2012)

Courses taught at IWU:

1. FYE 101: First-year Experience – Analytical Titans
2. Gateway 100: Galileo and the Politics of Science, Analytical Titans
3. MATH 110: Finite Mathematics
4. MATH 120X/220/320/420: Math Immersion I/II/III/IV
5. MATH/CS 135: Applications of Sets Logic and Recursion
6. MATH/CS 136: Computational Discrete Math
7. MATH 142: Computations and Statistical Methods for Healthcare
8. MATH 165: Analysis I

9. MATH 176 and 177: Applied Analysis I/II,
10. MATH 176/177/278: Calculus I/II/III
11. MATH 178: Calculus Lab with Mathematica
12. MATH/GRS/HIST 211: Mastering Space and Time in Pre-Modern Mathematics (team taught with Amy Coles)
13. MATH 215: Linear Algebra
14. MATH 310: Combinatorics and Graph Theory
15. MATH 270/370: Intro to Mathematical Research: Discrete Mathematics (team taught with Tian-Xiao He)
16. MATH 397: Internship
17. UNIV 297/397: Internship
18. MATH 412: Combinatorial Designs
19. MATH 495: Independent Study
20. MATH 499: Research/Thesis

Courses taught at ISU:

1. MATH 145: Calculus 1
2. MATH 175: Linear Algebra
3. MATH 260: Discrete Math
4. HON 285: Honors Undergraduate Research I
5. HON 286: Honors Undergraduate Research II
6. HON 299: Honors Independent Study
7. MATH 299: Independent Honors Study
8. MATH 363: Graph Theory

PEER REVIEWED PUBLICATIONS

1. Ugur Odabasi, Richard Low, and Dan Roberts, Preservation of the Z_k-antimagic Property of a Graph Under Edge Addition, submitted for peer-review.
2. Jacob Henry, Dan Roberts, and Patrick Ward, On Multidecompositions of Complete Directed Graphs into Directed Graph Pairs of Orders 3 and 4, *Journal of Combinatorial Mathematics and Combinatorial Computing*, accepted, awaiting publication.

3. R.C. Bunge, S.I. El-Zanati, J. Jetton, M. Juarez, A. Netz, D. Roberts, P. Ward, On loose 5-cycle packings, decompositions, and coverings of λ-fold complete 3-uniform hypergraphs, *Springer Proceedings in Mathematics and Statistics*, accepted, awaiting publication.

4. Ugur Odabasi, Richard Low, and Dan Roberts, The integer-antimagic spectra for a weak join of Hamiltonian graphs, *Theory and Applications of Graphs* 12 (2025), no. 1, article 5.

5. Ugur Odabasi, Richard Low, and Dan Roberts, The integer-antimagic spectra for a disjoint union of Hamiltonian graphs, *Turkish Journal of Mathematics* 46 (2022), no. 4, article 14, https://doi.org/10.55730/1300-0098.3161.

6. Richard Low and Dan Roberts, Application of the Combinatorial Nullstellensatz to Integer-magic Graph Labelings, *Theory and Applications of Graphs*, Vol. 9 (2022), Iss. 1, Article 3, doi: 10.20429/tag.2022.090103. https://digitalcommons.georgiasouthern.edu/tag/vol9/iss1/3

7. Richard Low and Dan Roberts, Constructing integer-magic graphs via the Combinatorial Nullstellensatz, *The Art of Discrete and Applied Mathematics* 5 (2022) p. 2.04, doi: 10.26493/2590-9770.1401.a6a.

8. Ugur Odabasi, Richard Low, and Dan Roberts, The integer-antimagic spectra of Hamiltonian graphs, *Electronic Journal of Graph Theory and its Applications*, 9 (2021), no. 2, 301–308.

9. Richard M. Low, Dan Roberts, Jinze Zheng, The integer-antimagic spectra of graphs with a chord, *Theory and Applications of Graphs* 8 (2021), no. 1, art. 1, 14pp.

10. R.C. Bunge, S.I. El-Zanati, K.A. Hawken, E. Ramirez, D.P. Roberts, E. Rodriguez-Guzman, J. Williams Jr., The spectrum problem for some digraphs of order 4 and size 6, *Journal of Combinatorial Mathematics and Combinatorial Computing* 114 (2020), 293–306.

11. H. Bermudez, R.C. Bunge, E.D. Cornelius, S.I. El-Zanati, W.H. Mamboleo, N.T. Nguyen, D.P. Roberts, The spectrum problem for two multigraphs with four vertices and seven edges, *Journal of Combinatorial Mathematics and Combinatorial Computing* 114 (2020), 31–45.

12. Yizhe Gao and Dan Roberts, Multidesigns for the graph pair formed by the 6-cycle and 3-prism, *Electronic Journal of Graph Theory and Applications* 8 no. 1, (2020).

13. R.C. Bunge, S.I. El-Zanati, L. Febles Miranda, J.P. Guadarrama, D.P. Roberts, E. Song, and A. Zale, On the λ-fold spectra of tripartite multigraphs of order 4 and size 5, *Ars Combinatoria* 144 (2019), 323–343.

14. R.C. Bunge, B.D. Darrow, T.M. Dubczuk, S. El-Zanati, H.H. Hao, G.L. Keller, G.A. Newkirk and D.P. Roberts, On decomposing the complete symmetric digraph into orientations of $K_4 - e$, *Discussiones Mathematicae Graph Theory* 39 (2019), no. 4, 815–828.

15. R.C. Bunge, M.K. Chwee, A.M. Cooper, S.I. El-Zanati, K.L. Kennedy, D.P. Roberts, C.C. Wilson, The spectrum for a multigraph on 4 vertices and 7 edges, *Congressus Numerantium*, 231 (2018), 239–248.

16. R.C. Bunge, S.I. El-Zanati, D.J. Gibson, D.P. Roberts, A.L. Sickman, L.A. States, J.T. Ward, The λ-fold spectrum problem for a multigraph on four vertices and eight edges, *Congressus Numerantium* 231 (2018), 249–257.

17. Ryan C. Bunge, Steven DeShong, Saad I. El-Zanati, Alexander Fischer, Dan Roberts, and Lawrence Teng, The Spectrum Problem for Digraphs of Order 4 and Size 5, *Opuscula Mathematica* **38**, no. 1 (2018).

18. Wenting Zhao, Mark H. Liffiton, Peter G. Jeavons, and Dan Roberts, Finding graph decompositions via SAT, *Proc. 29th IEEE International Conference on Tools with Artificial Intelligence (ICTAI 2017)*, 131–138.

19. Laban Cross, Edgar Morales, Dan Roberts, and Kellie Stilson, On cyclic decompositions of some complete directed graphs into antidirected cycles, *Congressus Numerantium*, 229 (2017), 353–359.

20. R.C. Bunge, J.A. Jeffries, J.N. Kirkpatrick, D.P. Roberts, and A.L. Sickman, Spectrum for multigraph designs on four vertices and six edges, *Congressus Numerantium*, 228 (2017), 29–49.

21. R.C. Bunge, C.J. Cowan, L.J. Cross, S.I. El-Zanati, A.E. Hart, D.P. Roberts, and A.M. Youngblood, Decompositions of Complete Digraphs into Small Tripartite Digraphs, *Journal of Combinatorial Mathematics and Combinatorial Computing*, **102** (2017), 239–251.

22. Dan Roberts and R.M. Low, Group-antimagic labelings of multi-cyclic graphs, *Theory and Applications of Graphs*, **3** (1) article 6 (2016).

23. R.C. Bunge, S.I. El-Zanati, J. Klister, D.P. Roberts, and C. Ruddell, On ordered directed ρ-labelings of bipartite digraphs and cyclic digraph decompositions, *Journal of Combinatorial Mathematics and Combinatorial Computing*, **99** (2016), 255-268.

24. R.C. Bunge, S.I. El-Zanati, H.J. Fry, K.S. Krauss, D.P. Roberts, C.A. Sullivan, A.A. Unsicker, and N.E. Witt, On the spectra of bipartite directed subgraphs of K_4^*, *Journal of Combinatorial Mathematics and Combinatorial Computing*, **98** (2016), 375–390.

25. D.G. Hoffman and Dan Roberts, Maximum packings of K_n with k-stars, *Australas. J. Combinatorics*, **59** (1) (2014), 206–210.

26. D.G. Hoffman and Dan Roberts, Embedding partial k-star designs, *Journal of Combinatorial Designs*, **22** (4) (2014), 161–170.

27. Atif Abueida and Dan Roberts, Uniform k-distant even trees are harmonious, *Utilitas Math.* 78 (2009), 279–285.

PROFESSIONAL TALKS

1. "Using the Combinatorial Nullstellensatz to find Z_p-magic graphs" MAA MathFest 2024, Saturday, August 10, 2024, Indianapolis, IN.

2. "Using the Combinatorial Nullstellensatz to find Z_p-magic graphs" Illinois State University DiscMath Seminar, Thursday, November 4, 2021, Normal, IL.

3. "Math is Your Friend" McLean County Museum of History Lunch and Learn series, October 14, 2021, Bloomington, IL (virtual).

4. "Problems that defy computation" Illinois State University DiscMath Seminar, Thursday, October 11, 2018, Normal, IL.

5. "On the spectra of orientations of $K_4 - e$" 32nd Midwestern Conference on Combinatorics and Combinatorial Computing, October 6, 2018, Duluth, MN.

6. "Multidesigns for a graph pair of order 6" Michigan Technological University, Thursday, August 9, 2018, Houghton, MI.

7. "Decompositions of complete multigraphs into small-order multigraphs" Illinois State University DiscMath Seminar, Wednesday, April 5, 2018, Normal, IL.

8. "Decompositions of complete multigraphs into certain multigraphs with 4 vertices and 7 edges" 31st Midwestern Conference on Combinatorics, Cryptography, and Combinatorial Computing, October 21, 2017, University of West Georgia, Carrollton, GA.

9. "On cyclic decompositions of complete digraphs into antidirected cycles" 48th Southeastern International Conference on Combinatorics, Graph Theory, and Computing, Thursday, March 9, 2017, Florida Atlantic University, Boca Raton, FL.

10. "Embedding partial k-star designs" Illinois State University DiscMath Seminar, Wednesday, March 23, 2016, Normal, IL.

11. "Problems That Defy Computation" Illinois State Undergraduate Mathematics Colloquium, Wednesday, March 30, 2016, Normal, IL.

12. Invited talk: "Graph theory origin story" University of Dayton Undergraduate Mathematics Day, Saturday, November 7, 2015, Dayton, Ohio.

13. "Multidecompositions of complete graphs into a graph pair of order 6" 29th Midwestern Conference on Combinatorics, Cryptography, and Combinatorial Computing, October 17, 2015, Charleston, SC.

14. "Multidecompositions of complete graphs into a graph pair of order 6" Illinois State University DiscMath Seminar, Thursday, April 16, 2015, Normal, IL.

15. "Multidecompositions of complete graphs into a graph pair of order 6" 46th Southeastern International Conference on Combinatorics, Graph Theory, and Computing, Wednesday, March 4, 2015, Boca Raton, FL.

16. "The group-antimagic labeling problem" Illinois State University DiscMath Seminar, Thursday, Nov. 13, 2014. Normal, IL.

17. "Group-antimagic labelings of graphs" MAA MathFest 2014. Portland, OR.

18. "Rosa-type labelings of directed graphs" Illinois State University REU 2014. Normal, IL.

19. "How to connect the World Cup and antimagic graphs" Illinois Wesleyan University, PME/Beling talk, Thursday, November 21, 2013. Bloomington, IL.

20. "Maximum packings of complete graphs with stars" Illinois State University DiscMath Seminar. Thursday, September 19, 2013. Normal, IL.

21. "How to pack stars into complete graphs" Illinois State University REU 2013. Normal, IL.

22. "Embedding Star Designs" AMS Southeastern Sectional Spring Meeting 2012. Tampa, FL. Session for Contributed Papers I. (1079-05-394). Saturday, March 10, 2012.

23. "Embedding Partial k-star Decompositions of K_n" 43rd Southeastern International Conference on Combinatorics, Graph Theory, and Computing, Friday, March 9, 2012. Boca Raton, FL.

24. "Maximum packings of complete graphs with stars" Joint Mathematics Meetings 2012, Boston, MA. Friday, January 6, 2012. AMS Session on Combinatorics and Graph Theory VI.

25. "Packing complete graphs with k-stars" MathFest 2011, Lexington, KY. Saturday, August 6, 2011. Special session: Great Talks for a General Audience: Coached Presentations by Graduate Students.

26. "On Hyperstar Decompositions of Hypergraphs" AMS Central Sectional Fall Meeting 2010. Notre Dame, IN. Session for Contributed Papers I. (1064-05-72). Saturday, November 6, 2010.

27. "On Hyperstar Decompositions of Hypergraphs" Auburn University Combinatorics Seminar. November 2010.

28. "Almost Resolvable 2-star Decompositions of the complete graph" Auburn University Combinatorics Seminar (masters presentation). December 2009.

29. "Uniform k-distant even trees are harmonious" Reporting on research done in an independent study. University of Dayton. March, 2007.

30. "Uniform k-distant even trees are harmonious" Poster session, Stander Symposium, University of Dayton, 2007.

CONFERENCES ATTENDED

1. MAA MathFest 2024, Indianapolis, IN, August 2024.

2. 34th Midwestern Conference on Combinatorics and Combinatorial Computing, ISU, Normal, IL, October 2022.

3. Illinois Sectional meeting of the MAA, spring 2020 – registered but canceled due to COVID.

4. AMS Central Sectional meeting 2019, Madison, Wisconsin, Special Session on Topics in Graph Theory and Combinatorics – attended and gave a talk.

5. MAA Mathfest 2019, Cincinnati, OH – attended.

6. Joint Mathematics Meetings 2019, Baltimore, MD – attended and interviewed candidates.

7. 2nd McLean County STEM Gala, April 2018, Illinois State University – attended.

8. 49th Southeastern International Conference on Combinatorics, Graph Theory, and Computing, March 2018, Florida Atlantic University, Boca Raton, FL – attended and had 2 students give talks.

9. 31st Midwestern Conference on Combinatorics and Combinatorial Computing, October 2017, University of West Georgia, Carrollton, GA – attended, gave a talk, and had 3 students give talks.

10. 48th Southeastern International Conference on Combinatorics, Graph Theory, and Computing, March 2017, Florida Atlantic University, Boca Raton, FL – attended and gave a talk.

11. 30th Midwestern Conference on Combinatorics and Combinatorial Computing held in honor of Mike Plantholt, October 2016, Illinois State University, Normal, Illinois – organizing committee member.

12. 3rd International Symposium on Riordan Arrays and Related Topics, June 2016, Illinois Wesleyan University, Bloomington, IL – organizing committee member.

13. 57th Midwest Graph Theory Conference, April 2016, Wright State University, Dayton, OH – attended.

14. Auburn Conference on Designs, Graphs, and Codes, January 2016, Auburn University, Auburn, AL – attended.

15. Undergraduate Mathematics Day, November 2015, University of Dayton, Dayton, OH – attended and gave an invited talk.

16. 29th Midwestern Conference on Combinatorics, Cryptography, and Combinatorial Computing, October 2015, Charleston, SC – attended and gave a talk.

17. 46th Southeastern International Conference on Combinatorics, Graph Theory, and Computing, April 2015, Boca Raton, FL – attended and gave a talk.

18. MAA MathFest 2014, Portland, OR – attended and gave a talk.

19. Joint Mathematics Meetings 2014, Baltimore, MD – attended.

20. MAA MathFest 2013, Hartford, CT – attended.

21. 2013 Legacy of R.L. Moore Conference, Austin, TX – attended.

22. AMS Southeastern Sectional Spring Meeting 2012, Tampa, FL – attended and gave a talk.

23. 43rd Southeastern International Conference on Combinatorics, Graph Theory, and Computing, 2012, Boca Raton, FL – attended and gave a talk.

24. Joint Mathematics Meetings 2012, Boston, MA – attended and gave a talk.

25. MAA MathFest 2011, Lexington KY – attended and gave a talk.

26. AMS Central Sectional Fall Meeting 2010, Notre Dame Univ. – attended and gave a talk.

27. Graduate Student Combinatorics Conference 2010, Auburn, AL – co-organized and attended.

28. Graduate Student Combinatorics Conference 2009, Lexington KY – attended.

RESEARCH INTERESTS

Combinatorics, Graph Theory, Design Theory, Hypergraphs, Graph Decompositions, Embeddings, Graph Labelings.

UNDERGRADUATE RESEARCH PROJECTS (IWU students listed with graduation years)

1. Ryen Kirschner '26. Summer 2025 Beling research student. We worked on characterizing the possible leaves of maximum packings of complete graphs with 6-stars and 7-stars. Ryen phrased the problem as an integer programming problem. Experimentation was conducted using MATLAB, and some general patterns were recognized for approaching the general problem for k-stars. A poster was presented on campus during fall 2025.

2. Amari Baeza '26, Islam Batyrbekov '25, Jade Kaminska '25, Sam Kedzior '26, Ryen Kirschner '26. Worked as a group with two subgroups during summer 2024. Amari, Sam, and Ryen through the Noyce scholars program, and Jade as a Beling summer student. The topic was group-magic labelings of cycles with two chords. A 5-day high school lesson plan was also created to implement these ideas in a classroom.

3. Zihan Nie '23, Alika Rakhimova '25, Alex Furcoiu (ISU), and Natalie Klosowski (ISU). Working as a group during summer 2023 on applying the Combinatorial Nullstellensatz to integer-magic labelings of graphs.

4. Honors research at IWU. Zihan Nie '23. Honors research awarded spring 2023 entitled Constructing the Spectrum of Maximum Packings with Stars of Size Six. She also solved the problem for stars of size seven.

5. Alex Furcoiu (ISU) and Natalie Klosowski (ISU). Both are part of the ISU honors program. Alex is a NexSTEM scholar. During fall 2022 they worked on reading through a paper about prime labelings of graphs. They prepared a report and critique of the paper, as well as extended the results a bit.

6. NexSTEM scholar Derek Vermeire (Heartland CC). During 2021-22 and 2022-23 academic years he worked on analyzing and extending a mathematical model for sales forecasting and volume for a small grocery store. Presentations each semester.

7. NexSTEM scholar Kade Murray '24. During the 2020-21 and 2021-22 academic years he worked on analyzing and extending a mathematical model for sales forecasting and volume for a small grocery store. Presentations each semester.

8. Honors research at IWU. Patrick Ward '20. Honors research awarded spring 2020. Summer REU at Illinois State University funded by the Beling departmental fund, and research project at IWU during 2018-19. He worked on three projects in graph decompositions: two at the

REU on hypergraphs and directed graphs, and one on directed graph pairs beginning fall 2018.

9. State Farm STEM fellowship at IWU, summer 2018. Zihan (Ice) Nie '23. This project is co-advised with Prof. Tian-Xiao He. Her work was on characterizing the leaves of maximum packings of complete graphs with 6-stars.

10. Co-directed, with Saad El-Zanati (PI) and Ryan Bunge, multiple groups of students working on research in graph theory at the Illinois State University Research Experience for Undergraduates (REU): summers 2014–18.

11. Daney Chen '18. During summer of 2017 she participated in the Illinois State University REU. Her group's work has been on decompositions of complete directed graphs into small directed graphs. In particular, they focused on orientations of certain multigraphs derived from the paw graph. In addition, she has independently worked on the problem of characterizing the leaves of maximum packings of complete graphs with 6-stars.

12. Honors research at IWU. Willian O'Conner '17. Honors research awarded spring 2017: "Counting multigraph pairs of λK_n." This was an extension of the work that William and Paul Johnson '19 conducted during the summer of 2016.

13. Honors research at IWU. Yizhe Gao '16. Honors research awarded spring 2016: "Multidecomposition of complete graphs into a graph pair of order 6." Poster at JWP 2013: *A look at multidecomposition of complete graphs into graph pairs of order 4.* Poster at JWP 2014: *Decomposing complete graphs into a graph pair of order 6.* Talk at JWP 2015: *Multidecompositions of complete graphs into a graph pair of order 6.*

14. Honors research at IWU. Jacob Henry '16. Honors research awarded spring 2016: *Decomposition of complete directed graphs into directed graph pairs of orders 3 and 4.* His work is an extension of the undirected version of this problem. He systematically classified which complete directed graphs will decompose into directed graph pairs of orders 3 and 4.

15. William O'Conner '17 and Paul Johnson '19. They worked on enumerating all multigraph pairs of a given order. This work is an extension of the simple graph version of the problem. William gave a talk at the 3rd International Symposium on Riordan Arrays and Related Topics hosted by IWU in June of 2016.

16. Jade Phung '17. She classified all complete graphs that admit a multidecomposition into a 7-cycle and the complement of a 7-cycle. Her work began in the fall of 2015 and commenced spring of 2016. This is part of the collective project that multiple students have worked on concerning multidecompositions of complete graphs into graph pairs. She also completed a project during May 2016 where she classified all complete graphs that admit a multidecomposition into K_3 and S_3.

17. Honors research at IWU. Kimberly Diller '15. Honors research awarded spring 2015: *Appending Stars to Uniform k-distant Trees: Preserving Gracefulness.* Also directed her research during 2013-14 academic year, and her Beling summer research 2014. She gave talks at JWP 2014, JWP 2015, the Illinois Section of the MAA meeting 2014, and her honors defense was given successfully on Friday, April 10, 2015.

18. Anh Phan '15. Project during 2013-14 academic year. Presented a talk at JWP 2014 entitled *Graph Pairs and Isomorphism*.

19. Anqi Zhang '15. Her research was on group-antimagic labelings of graphs, and focused on a class of graphs called caterpillars. She worked with me spring 2014 through Spring 2015.

20. Jinze Zheng '17. Her research was on group-antimagic labelings of graphs, and focused on two classes of graphs called closed helms and cycles with a chord. Her work began spring 2015 and was finished Spring 2016. She presented one talk and two posters at JWP throughout 2015-16.

University service at IWU:

1. Faculty Development Committee: Fall 2023 – Spring 25 (chair during 24-25).

2. Intellectual theme organizing committee (Power of Place), course cluster co-coordinator, academic year 2022-23.

3. Nominating Committee: Fall 2019, Fall 2020 – Spring 2021 (chair), Fall 2021 – Spring 2023

4. GREENetwork: Fall 2020 – Spring 2023

5. Gen. Ed. Task Force: member Summer 2017 – Spring 2018.

6. Undergraduate Research Advisory Committee: member Fall 2016 – Spring 2017, co-chair fall 2017 – spring 2018.

7. Study Abroad Committee: member Fall 2016 – Spring 2017 and Fall 2018 – Spring 2023.

8. Internship and Career Center Liaison Committee: member Fall 2014 – Spring 2016, Fall 2022 – Spring 2023.

9. JWP Research Conference Committee: member Fall 2014 – Spring 2016.

Math Department service:

1. Department chair: August 2024 – present.

2. Acting Department Chair: June/July 2018, December 2020 – July 2021, May 2022, May/June 2023.

3. Math curriculum major revision: Summer 2022.

4. Coordinator of the Math Immersion Sequence: 2020 – present.

5. Coordinator of sophomore and senior assessment tests: 2019 – present.

6. Calculus sequence major revision: 2019.

7. Organized Math Brown-bag Lunch series: 2014 – present.

8. Developed *TA and Lab Monitor Guidebook* for the Math department during 2014-15 academic year.
9. Developed the initial stages of a comprehensive support program for math majors at IWU, in conjunction with developing an NSF grant proposal: Summer 2014.
10. Manager of the department webpage: Fall 2013 – present.
11. Committee for Beling Endowed Chair Departmental Funds Allocation: Fall 2013 – present.
12. Developed departmental LaTeX manual for students: Spring 2014.

Service to IWU students:

1. Pi Mu Epsilon faculty advisor: 2020 – present.
2. Association for Women in Mathematics: IWU chapter faculty co-supervisor (with Prof. Drici): fall 2014 – present.
3. Accompanied two students to Illinois Section MAA conference: March 2014.
4. IWU Chess Club: faculty advisor Spring 2013 – present.
5. Supervisor of multiple student research projects.

Service to the mathematical community:

1. Editorial board, Journal of Combinatorial Mathematics and Combinatorial Computing (JCMCC), August 2024.
2. Member of organizing committee of 34th Midwestern Conference on Combinatorics and Combinatorial Computing, ISU, Normal, IL, October 2022.
3. Member of organizing committee of 30th Midwestern Conference on Combinatorics and Combinatorial Computing, ISU, Normal, IL, October 2016.
4. Member of organizing committee of 3rd International Symposium on Riordan Arrays and Related Topics, IWU, Bloomington, IL, June 2016.
5. Refereed articles for journals including: Electronic Journal of Combinatorics, Discrete Mathematics, Integers, Graphs and Combinatorics, Theory and Applications of Graphs, Mathematics and Sports, and International Journal of Mathematical Education in Science and Technology.
6. Reviewer for Math Reviews.
7. Book review: *STEM Calculus*, Wiley.
8. Judged various student talk/poster sessions at Mathfest and JMM.
9. Panel co-organizer for Project NExT: 2014 JMM.

10. Graduate Student Combinatorics Conference 2010, Auburn AL – co-organizer.

LANGUAGE SKILLS

Mathematica, Python, Scheme, and LaTeX.

PROFESSIONAL ORGANIZATIONS

Associate Fellow of the Institute for Combinatorics and its Applications (ICA).

American Mathematical Society – member.

HONORS

1. IWU internal grant. Artistic and Scholarly Development grant: Integer-magic labelings of maximal outer planar graphs, spring 2023. $3,500.00 total including $1,500.00 for summer student wages.

2. IWU internal grant. Curriculum Development grant (with Zahia Drici): Restructuring the math curriculum, summer 2022 – $4,000.00 total.

3. IWU internal grant. Artistic and Scholarly Development grant: Furthering our understanding of how to use the combinatorial nullstellensatz to construct graph labelings, summer 2022 – $2,000.00

4. IWU internal grant. Artistic and Scholarly Development grant (sabbatical funding): The construction of integer-antimagic labelings of graphs, spring 2020 – $3,500.00 total including $1,500.00 for student wages.

5. IWU internal grant. Artistic and Scholarly Development grant: Searching for hypergraph desings, spring 2019 – $3,500.00.

6. IWU internal grant. Mellon Center grant for developing a team-taught course with Prof. Amy Coles: Measuring space and time in pre-modern mathematics – $2,000.00.

7. IWU internal grant. Artistic and Scholarly Development grant: Optimally packing stars into complete graphs, summer 2017 – $3,500.00 total including $1,500.00 for student wages.

8. IWU internal grant. Curriculum Development grant (with Tian-Xiao He): Developing materials for a course in mathematical research, spring 2016 – $3,000.00.

9. Travel grant from Auburn University to attend Auburn Conference on Designs, Graphs, and Codes, January 2016 – $500.00.

10. IWU internal grant. Curriculum Development grant (with Zahia Drici): Developing a series of calculus modules with *Mathematica*, spring/summer 2015 – $5,000.00.

11. Travel Grant from the Academy of Inquiry Based Learning to attend the MAA PREP IBL workshop at Kenyon College, summer 2014 – $500.00.

12. IWU internal grant. Mellon Foundation: Integration of Information Literacy and Writing in the Disciplines, new assignment, fall 2014 – $500.00.

13. MAA Project NExT fellow 2013-14 – Brown13, Illinois Section member.