**The Probability of Sudoku: The Bounds of the Cardinality of Minimal Fair Sudoku Puzzles**

Harrison Engoren, Computer Science Major\_Ronald Herrygers, Mathematics Major\_Dr. Joshua Cooper, Department of Mathematics

**Background**

A **Sudoku puzzle** is an incomplete **Sudoku board**, which is a 9x9 matrix of numbers 1-9 placed so that no number appears twice in any row, column, or one of the nine 3x3 blocks; the numbers in the puzzle are referred to as clues or **givens**. A **determining set**, also known as a fair puzzle, is a Sudoku puzzle with exactly one unique solution. Of these determining sets, **critical sets** are the determining sets where none of the current givens in the puzzle can be removed without making the puzzle unfair [Cooper&Kirkpatrick]. Critical sets can be derived from determining sets simply by repeatedly removing givens that do not change the fairness of the puzzle until no such givens remain. Because of this, there is a set of critical subsets for every determining set, where the critical sets have varying **cardinalities**, or numbers of givens. Sudoku boards can also be created that are not 9x9 as long as they are in the form (*n*2)⨯(*n*2), such as 4x4, 16x16, and 100x100. **Equivalence classes** are groups of unique Sudoku puzzles with the same cardinality that have different solutions, but their only difference is in two squares. If the values of these two squares are switched for one puzzle, then it creates the other puzzle in the equivalence class (Ex. 1,2 and 2,1). It has been proven that there are 288 equivalence classes of 4x4 Sudoku boards [Oddson]. We also know that there are 5,472,730,538 equivalence classes of 9x9 Sudoku boards[Russell&Jarvis]. Many believe that 17 is the minimal number of clues for the 9x9, although we do not have a human-readable proof of this fact.

**Research Question**

What are the different possible cardinalities (i.e., the “spectrum”) of the critical sets? Included in this question, there are four simpler but still very interesting special cases. These cases involve finding the minimin, the maximin, the minimax, and the maximax: Over all determining sets, what is the smallest/largest cardinality of the smallest/largest critical set? We will study the distribution of the spectrum in general, looking for patterns (and explanations for those patterns) in their means, extrema, variances, etc.

**Project Goals and Objectives**

Our main goal for this project is to acquire a good understanding of the critical set spectrum. This means that we observe range and frequencies of the cardinalities of all the unique critical sets of Sudoku. We also plan to answer our four branching questions for 4x4 Sudoku puzzles, and explore the four branching questions for the 9x9 and general (*n*2)⨯(*n*2) Sudoku puzzles. Once we have completed these tasks, we will create a finalized mathematical proof stating the conclusions we have made about the critical set spectrum of Sudoku puzzles.

**Project Impact**

Although it may not be immediately recognizable, Sudoku has strong ties to one of modern mathematics’ major field of research, graph theory. If you consider each cell in the Sudoku puzzle to be a vertex and place an edge between vertices if they are in the same row, column, or block, then you have successfully represented a Sudoku board as a graph. We can then imagine the Sudoku problem as a graph coloring problem: a *proper* coloring of this “Sudoku graph” is precisely a complete Sudoku board. Graph coloring problems also have many valuable real-world applications, such as the famous Four Color problem or scheduling committee meetings [Rehmeyer]. Progress made in proving theorems for these seemingly simple Sudoku puzzles may offer insight into other areas of graph theory and beyond.

**Project Design**

As a group research project, we will be working jointly on each of the following tasks. Initially we will focus on 4x4 Sudoku puzzles because of their similarity to 9x9 boards while having a much smaller and more easily manageable number of puzzles to check. Our initial plan is to convert our spectrum problem into a series of satisfiability problems, which we will then run in a free world-class satisfiability solver, or SAT solver. These **satisfiability problems** consist of finding truth assignments to variables that together satisfy a given Boolean formula. Because a critical set is a determining set of minimal size, the SAT solver will allow us to minimize determining sets into critical sets, of which the cardinality will be noted. Dr. Cooper will assist us with production of the satisfiability problems and train us on how to effectively use the SAT solver. Restating our problem with mathematical logic will allow us to convert the problem into a satisfiability problem, which we have already partially worked through. Once these satisfiability problems are set into place and working properly, we will increase the scale of these methods so that they will work on 9x9 puzzles and (*n*2)⨯(*n*2) puzzles. We will also be looking for patterns and tendencies in the 4x4 data because they will greatly assist us when looking at the 9x9 and the (*n*2)⨯(*n*2).

**Project Timeline**

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| --- | --- | --- | --- | --- |
| **Task / Months - 2017** | **Jan** | **Feb** | **Mar** | **Apr** |
| Write Satisfiability Problems |  |  |  |  |
| Run Solver, Analyze Data |  |  |  |  |
| Extend to 9x9, (*n*2)⨯(*n*2) |  |  |  |  |
| Write Proof, Presentation |  |  |  |  |
| Presentation |  |  |  |  |

To start, we will transform Sudoku puzzles into a satisfiability problem so that we may easily determine the number of correct solutions for a given Sudoku puzzle. Once we have devised our satisfiability problem, we can use it with the solver to find the critical and determining sets for all 288 equivalence classes for the 4x4 Sudoku board. This information will allow us to construct a histogram, analyze our data, and prove theorems about the statistical characteristics of 4x4 Sudoku boards. Once we have proven some properties about the 4x4 Sudoku board, we will then try to extrapolate our findings to the traditional 9x9 Sudoku board and general (*n*2)⨯(*n*2) cases. Finally, we will work on publishing our findings and putting together a presentation for Discovery Day and MAA MathFest.

**Anticipated Results**

We expect to completely answer our research question and the four extended questions for the 4x4 Sudoku puzzles. Once we have done this, we hope to extend our results towards setting bounds for the spectrum of 9x9 Sudoku puzzles. We also plan to explore other (*n*2)⨯(*n*2) puzzles with this information, obtaining bounds that are functions of *n*. The resulting theorems and computational results will be written up as posters and presented at Discovery Day and MAA MathFest 2017 (July 26-29), Chicago, IL.

**Personal Statement**

**Engoren –**

Although I am a Computer Science major, taking Discrete Mathematics with Dr. Cooper opened me up to an entirely new field of interest. I have always enjoyed my math classes, but only recently did I discover what truly comprises *mathematics*. After reading *The Man Who Loved Only Numbers: The Story of Paul Erdos*, I wanted to immerse myself in the theories and proofs of higher-order mathematics, as opposed to the computational mathematics taught throughout high school. Now, I can take a common man’s puzzle (Sudoku) and delve into the properties it has and what those properties represent in the greater scheme of mathematics. This project presents challenges to improve my critical thinking and abstract reasoning abilities beyond anything I could attain from the classroom. Furthermore, the opportunity to present at the MAA MathFest would allow me to share with and learn from other mathematicians across the country. Overall, the problem solving experience and research exposure that the Magellan Scholarship would offer are crucial in both academia and industry and will follow me regardless of what my future holds.

**Herrygers –**

I am engaging in research mainly for the purpose of learning and experiencing mathematical research. As a second semester student who is majoring in mathematics, I do not yet know what I want to do specifically once I receive my math degree. I chose to major in Mathematics because math always came easily to me. I assumed that I could find an interesting field of work based around my academic strengths. This research will give me more experience and knowledge of the different aspects of mathematics so that I can better understand exactly which aspect of mathematics I will decide to focus on later on in my mathematics career. The MAA MathFest conference will provide plenty of different ideas and fields of mathematics for me to observe. Presenting at Discovery Day and MAA MathFest will improve my presentation skills, which will certainly aid me later on. I will also be able to include the MAA MathFest presentation on future resumes to help distinguish myself from other applicants when applying for a job.

**References**

Cooper, J., Kirkpatrick, A. *Critical Sets for Sudoku and General Graph Colorings.* Discrete Mathematics, University of South Carolina. Columbia, SC. 2013.

McGuire, G., Tugemann, B. G. Civario, There is no 16-clue Sudoku: Solving the Sudoku minimum number of clues problem, preprint (2012).

Oddson, K. *Math and Sudoku: Exploring Sudoku Boards Through Graph Theory, Group Theory, and Combinatorics.* Portland State University. 2016.

Rehmeyer, J. “Sudoku and Graph Theory.” *ScienceNews.* 3 July 2007, <https://www.sciencenews.org/article/sudoku-and-graph-theory>. Accessed 13 October 2016.

Russel, Ed., Jarvis, F. *Mathematics of Sudoku II.* University of Sheffield. 2006.

For instructions on completing this form: <http://www.sc.edu/our/doc/BUDGETInstructionsforWORD.pdf>

**Magellan Scholar BUDGET FORM**

Student’s Name: Harrison Engoren

**Double-click on table to enter data**

**Budget Justification/Description**

**NOTE:** Magellan Scholar awards are processed through “E” funds. All expenditures MUST remain compliant with E fund procurement requirements. All budgets must be reviewed by department business managers prior to submission.

**Student Salary:** Indicate estimated number of student research hours per week and hourly rate separated by semesters when student is enrolled in classes or not enrolled in classes (generally fall or spring vs summer semesters). Time during breaks (Fall, Winter or Spring break) are still hours during semesters of enrolled classes.

While taking classes: 10 hours per week for 15 weeks at $10.00 per hour

**Materials/Supplies:** Indicate items, quantity, and estimated price. *Be sure to include taxes on all purchases.*

***Are you requesting funds for participant incentives?*** *You must attach an approval memo from business manager – see guidebook.*

Discovery Day poster printing: $50

**Travel:** Indicate location, purpose of travel, provide **itemized** costs (list out each cost separately: transportation, lodging, registration, etc).  For conferences, provide name of conference, dates, and explain why this conference is most appropriate. *No more than $1000 is permitted for conference travel.*

MAA MathFest 2017 (July 26-29), Chicago, IL

Airfare (roundtrip): $532 (from Kayak, CAE to ORD)

Lodging: $169/night (incl tax) for 4 nights at conference hotel Hilton Chicago @50% +17.4% tax = $397

Meals: $32/day for 4 days = $128

Taxis (to and from airport) = $60

Registration: $89

TOTAL: $1206  (~$1000 will be used toward travel from Magellan Scholar program; student will seek

additional funds from department or will cover expenses out of pocket)

For instructions on completing this form: <http://www.sc.edu/our/doc/BUDGETInstructionsforWORD.pdf>

**Magellan Scholar BUDGET FORM**

Student’s Name: Ronald Herrygers

**Double-click on table to enter data**

**Budget Justification/Description**

**NOTE:** Magellan Scholar awards are processed through “E” funds. All expenditures MUST remain compliant with E fund procurement requirements. All budgets must be reviewed by department business managers prior to submission.

**Student Salary:** Indicate estimated number of student research hours per week and hourly rate separated by semesters when student is enrolled in classes or not enrolled in classes (generally fall or spring vs summer semesters). Time during breaks (Fall, Winter or Spring break) are still hours during semesters of enrolled classes.

While taking classes: 10 hours per week for 15 weeks at $10.00 per hour

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***Are you requesting funds for participant incentives?*** *You must attach an approval memo from business manager – see guidebook.*

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Taxis (to and from airport) = $60

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TOTAL: $1206  (~$1000 will be used toward travel from Magellan Scholar program; student will seek

additional funds from department or will cover expenses out of pocket)

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| **Transcript Data** | | | | | | | | | | | |
| **STUDENT INFORMATION** | | | | | | | | | | | |
| **Name :** | | Harrison M. Engoren | | | | | | | | | |
| **Birth Date:** | | 02-OCT | | | | | | | | | |
| **Student Type:** | | Continuing | | | | | | | | | |
| **Curriculum Information** | | | | | |  |  |  |  |  |  |
| **Current Program** | | | | | |  |  |  |  |  |  |
| Bachelor Sci in Computer Sci | | | | | |  |  |  |  |  |  |
| **College:** | | | College of Engr & Computing | | |  |  |  |  |  |  |
| **Campus:** | | | USC Columbia | | |  |  |  |  |  |  |
| **Major:** | | | Computer Science | | |  |  |  |  |  |  |
| **Major Concentration:** | | | No Concentration | | |  |  |  |  |  |  |
| **Minor:** | | | Business Administration | | |  |  |  |  |  |  |
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| **Spring 2013:** | Advanced Placement Exam | | | | | | | | | | |
| **Subject** | **Course** | | **Title** | | | **Grade** | **Credit Hours** | **Quality Points** | | | | **R** |
| HIST | 111 | | US History to 1865 | | | CR | 3.000 | 0.00 | | | |  |
| HIST | 112 | | US History Since 1865 | | | CR | 3.000 | 0.00 | | | |  |
|  | | | | **Attempt Hours** | **Passed Hours** | **Earned Hours** | **GPA Hours** | **Quality Points** | **GPA** | | |  |
| **Current Term:** | | | | 0.000 | 0.000 | 6.000 | 0.000 | 0.00 | 0.000 | | |  |
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| **Spring 2014:** | Advanced Placement Exam | | | | | | | | | | |  |
| **Subject** | **Course** | | **Title** | | | **Grade** | **Credit Hours** | **Quality Points** | | | | **R** |
| ENGL | 101 | | Critical Reading & Comp | | | CR | 3.000 | 0.00 | | | |  |
| ENGL | 102 | | Rhetoric and Composition | | | CR | 3.000 | 0.00 | | | |  |
| MATH | 141 | | Calculus I | | | CR | 4.000 | 0.00 | | | |  |
| MATH | 142 | | Calculus II | | | CR | 4.000 | 0.00 | | | |  |
| POLI | 201 | | American National Government | | | CR | 3.000 | 0.00 | | | |  |
|  | | | | **Attempt Hours** | **Passed Hours** | **Earned Hours** | **GPA Hours** | **Quality Points** | **GPA** | | |  |
| **Current Term:** | | | | 0.000 | 0.000 | 17.000 | 0.000 | 0.00 | 0.000 | | |  |
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| |  | | --- | | Unofficial Transcript | | | | |  |  |  |  |  |  |  |  |  |
| **Spring 2015:** | Advanced Placement Exam | | | | | | | | | | |  |
| **Subject** | **Course** | | **Title** | | | **Grade** | **Credit Hours** | **Quality Points** | | | | **R** |
| CSCE | 145 | | Algorithmic Design I | | | CR | 4.000 | 0.00 | | | |  |
| PHYS | 211 | | Essentials of Physics I | | | CR | 3.000 | 0.00 | | | |  |
| PHYS | 211L | | Essentials of Physics I Lab | | | CR | 1.000 | 0.00 | | | |  |
| PHYS | 212 | | Essentials of Physics II | | | CR | 3.000 | 0.00 | | | |  |
| PHYS | 212L | | Essentials of Physics II Lab | | | CR | 1.000 | 0.00 | | | |  |
|  | | | | **Attempt Hours** | **Passed Hours** | **Earned Hours** | **GPA Hours** | **Quality Points** | **GPA** | | |  |
| **Current Term:** | | | | 0.000 | 0.000 | 12.000 | 0.000 | 0.00 | 0.000 | | |  |
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| **Term: Fall 2015** | | | | | | | | | | | |  |
| **College:** | | | | College of Engr & Computing | | | | | | |  |  |
| **Major:** | | | | Computer Science | | | | | | |  |  |
| **Student Type:** | | | | New Freshman | | | | | | |  |  |
| **Academic Standing:** | | | | Good Standing | | | | | | |  |  |
| **Additional Standing:** | | | | Dean's List | | | | | | |  |  |
| **Subject** | **Course** | **Campus** | **Level** | **Title** | | **Grade** | **Credit Hours** | **Quality Points** | **Start and End Dates** | **R** | **CEUContact Hours** |  |
| CSCE | 146 | USC Columbia | UG | Algorithmic Design II | | A | 4.000 | 16.00 |  |  |  |  |
| CSCE | 190 | USC Columbia | UG | Computing in the Modern World | | A | 1.000 | 4.00 |  |  |  |  |
| CSCE | 211 | USC Columbia | UG | HNRS: Digital Logic Design | | A | 3.000 | 12.00 |  |  |  |  |
| CSCE | 215 | USC Columbia | UG | UNIX/Linux Fundamentals | | A | 1.000 | 4.00 |  |  |  |  |
| MATH | 241 | USC Columbia | UG | HNRS: Vector Calculus | | B+ | 3.000 | 10.50 |  |  |  |  |
| SCHC | 385 | USC Columbia | UG | HNRS: Topic: Pestilence, Plague, and Contagion in the Western Tradition | | A | 3.000 | 12.00 |  |  |  |  |
| **Term Totals (Undergraduate)** | | | | | | | | | | | |  |
|  | | | | | **Attempt Hours** | **Passed Hours** | **Earned Hours** | **GPA Hours** | **Quality Points** | **GPA** | |  |
| **Current Term:** | | | | | 15.000 | 15.000 | 15.000 | 15.000 | 58.50 | 3.900 | |  |
| **Cumulative:** | | | | | 15.000 | 15.000 | 15.000 | 15.000 | 58.50 | 3.900 | |  |
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| |  | | --- | | Unofficial Transcript | | | | |  |  |  |  |  |  |  |  |  |
| **Term: Spring 2016** | | | | | | | | | | | |  |
| **College:** | | | | College of Engr & Computing | | | | | | |  |  |
| **Major:** | | | | Computer Science | | | | | | |  |  |
| **Student Type:** | | | | Continuing | | | | | | |  |  |
| **Academic Standing:** | | | | Good Standing | | | | | | |  |  |
| **Additional Standing:** | | | | Dean's List | | | | | | |  |  |
| **Last Academic Standing:** | | | | Good Standing | | | | | | |  |  |
| **Subject** | **Course** | **Campus** | **Level** | **Title** | | **Grade** | **Credit Hours** | **Quality Points** | **Start and End Dates** | **R** | **CEUContact Hours** |  |
| CSCE | 212 | USC Columbia | UG | HNRS: Introduction to Computer Architecture | | A | 3.000 | 12.00 |  |  |  |  |
| CSCE | 240 | USC Columbia | UG | Intro to Software Engineering | | A | 3.000 | 12.00 |  |  |  |  |
| ECON | 224 | USC Columbia | UG | HNRS: Introduction to Economics | | A | 3.000 | 12.00 |  |  |  |  |
| GEOL | 101 | USC Columbia | UG | Introduction to the Earth | | A | 4.000 | 16.00 |  |  |  |  |
| LIBR | 101 | USC Columbia | UG | Information Literacy | | A | 1.000 | 4.00 |  |  |  |  |
| MATH | 574 | USC Columbia | UG | Discrete Mathematics I | | B | 3.000 | 9.00 |  |  |  |  |
| **Term Totals (Undergraduate)** | | | | | | | | | | | |  |
|  | | | | | **Attempt Hours** | **Passed Hours** | **Earned Hours** | **GPA Hours** | **Quality Points** | **GPA** | |  |
| **Current Term:** | | | | | 17.000 | 17.000 | 17.000 | 17.000 | 65.00 | 3.824 | |  |
| **Cumulative:** | | | | | 32.000 | 32.000 | 32.000 | 32.000 | 123.50 | 3.859 | |  |
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| |  | | --- | | Unofficial Transcript | | | | |  |  |  |  |  |  |  |  |  |
| **TRANSCRIPT TOTALS (UNDERGRADUATE)**[**-Top-**](https://ssb.onecarolina.sc.edu/BANP/bwskotrn.P_ViewTran#top) | | | | | | | | | | |  |  |
|  | | | | **Attempt Hours** | **Passed Hours** | **Earned Hours** | **GPA Hours** | **Quality Points** | **GPA** | |  |  |
| **Total Institution:** | | | | 32.000 | 32.000 | 32.000 | 32.000 | 123.50 | 3.859 | |  |  |
| **Total Transfer:** | | | | 0.000 | 0.000 | 35.000 | 0.000 | 0.00 | 0.000 | |  |  |
| **Overall:** | | | | 32.000 | 32.000 | 67.000 | 32.000 | 123.50 | 3.859 | |  |  |
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| |  | | --- | | Unofficial Transcript | | | | |  |  |  |  |  |  |  |  |  |
| **COURSES IN PROGRESS**[**-Top-**](https://ssb.onecarolina.sc.edu/BANP/bwskotrn.P_ViewTran#top) | | | | | | | | | | |  |  |
| **Term: Fall 2016** | | | | | | | | | | |  |  |
| **College:** | | | | College of Engr & Computing | | | | | | |  |  |
| **Major:** | | | | Computer Science | | | | | | |  |  |
| **Student Type:** | | | | Continuing | | | | | | |  |  |
| **Subject** | **Course** | **Campus** | **Level** | **Title** | | | **Credit Hours** | | **Start and End Dates** | |  |  |
| CSCE | 311 | USC Columbia | UG | Operating Systems | | | 3.000 | |  | |  |  |
| CSCE | 330 | USC Columbia | UG | Programming Language Structures | | | 3.000 | |  | |  |  |
| CSCE | 350 | USC Columbia | UG | Data Structures and Algorithms | | | 3.000 | |  | |  |  |
| CSCE | 390 | USC Columbia | UG | Professional Issues in Computer Science and Engineering | | | 1.000 | |  | |  |  |
| MATH | 499 | USC Columbia | UG | Undergraduate Research | | | 2.000 | |  | |  |  |
| SCHC | 359 | USC Columbia | UG | HNRS: Chance and Randomness | | | 3.000 | |  | |  |  |
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| **Transcript Data** | | | | | | | | | | | |
| **STUDENT INFORMATION** | | | | | | | | | | | |
| **Name :** | | Ronald A. Herrygers | | | | | | | | | |
| **Birth Date:** | | 12-APR | | | | | | | | | |
| **Student Type:** | | Continuing | | | | | | | | | |
| **Curriculum Information** | | | | | |  |  |  |  |  |  |
| **Current Program** | | | | | |  |  |  |  |  |  |
| Bachelor of Science | | | | | |  |  |  |  |  |  |
| **College:** | | | College of Arts and Sciences | | |  |  |  |  |  |  |
| **Campus:** | | | USC Columbia | | |  |  |  |  |  |  |
| **Major:** | | | Mathematics | | |  |  |  |  |  |  |
| **Major Concentration:** | | | No Concentration | | |  |  |  |  |  |  |
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| \*\*\*Transcript type:ADVS Advising is NOT Official \*\*\* | | | | | | | | | | | |
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| **Spring 2015:** | Advanced Placement Exam | | | | | | | | | | |
| **Subject** | **Course** | | **Title** | | | **Grade** | **Credit Hours** | **Quality Points** | | | | **R** |
| LATN | 121 | | Elementary Latin | | | CR | 4.000 | 0.00 | | | |  |
| LATN | 122 | | Basic Proficiency in Latin | | | CR | 3.000 | 0.00 | | | |  |
| MATH | 141 | | Calculus I | | | CR | 4.000 | 0.00 | | | |  |
|  | | | | **Attempt Hours** | **Passed Hours** | **Earned Hours** | **GPA Hours** | **Quality Points** | **GPA** | | |  |
| **Current Term:** | | | | 0.000 | 0.000 | 11.000 | 0.000 | 0.00 | 0.000 | | |  |
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| **Term: Fall 2015** | | | | | | | | | | | |  |
| **College:** | | | | College of Arts and Sciences | | | | | | |  |  |
| **Major:** | | | | Mathematics | | | | | | |  |  |
| **Student Type:** | | | | New Freshman | | | | | | |  |  |
| **Academic Standing:** | | | | Good Standing | | | | | | |  |  |
| **Additional Standing:** | | | | President's List/Dean's List | | | | | | |  |  |
| **Subject** | **Course** | **Campus** | **Level** | **Title** | | **Grade** | **Credit Hours** | **Quality Points** | **Start and End Dates** | **R** | **CEUContact Hours** |  |
| CHEM | 111 | USC Columbia | UG | General Chemistry I | | A | 3.000 | 12.00 |  |  |  |  |
| CHEM | 111L | USC Columbia | UG | General Chemistry I Lab | | A | 1.000 | 4.00 |  |  |  |  |
| ENGL | 101 | USC Columbia | UG | Critical Reading & Comp | | A | 3.000 | 12.00 |  |  |  |  |
| MATH | 142 | USC Columbia | UG | Calculus II | | A | 4.000 | 16.00 |  |  |  |  |
| PEDU | 112 | USC Columbia | UG | Basketball | | A | 1.000 | 4.00 |  |  |  |  |
| UNIV | 101 | USC Columbia | UG | The Student in the University | | A | 3.000 | 12.00 |  |  |  |  |
| **Term Totals (Undergraduate)** | | | | | | | | | | | |  |
|  | | | | | **Attempt Hours** | **Passed Hours** | **Earned Hours** | **GPA Hours** | **Quality Points** | **GPA** | |  |
| **Current Term:** | | | | | 15.000 | 15.000 | 15.000 | 15.000 | 60.00 | 4.000 | |  |
| **Cumulative:** | | | | | 15.000 | 15.000 | 15.000 | 15.000 | 60.00 | 4.000 | |  |
|  | | | | | | | | | | | |  |
| |  | | --- | | Unofficial Transcript | | | | |  |  |  |  |  |  |  |  |  |
| **Term: Spring 2016** | | | | | | | | | | | |  |
| **College:** | | | | College of Arts and Sciences | | | | | | |  |  |
| **Major:** | | | | Mathematics | | | | | | |  |  |
| **Student Type:** | | | | Continuing | | | | | | |  |  |
| **Academic Standing:** | | | | Good Standing | | | | | | |  |  |
| **Additional Standing:** | | | | Dean's List | | | | | | |  |  |
| **Last Academic Standing:** | | | | Good Standing | | | | | | |  |  |
| **Subject** | **Course** | **Campus** | **Level** | **Title** | | **Grade** | **Credit Hours** | **Quality Points** | **Start and End Dates** | **R** | **CEUContact Hours** |  |
| CHEM | 112 | USC Columbia | UG | General Chemistry II | | A | 3.000 | 12.00 |  |  |  |  |
| CHEM | 112L | USC Columbia | UG | General Chemistry II Lab | | B+ | 1.000 | 3.50 |  |  |  |  |
| CSCE | 145 | USC Columbia | UG | Algorithmic Design I | | A | 4.000 | 16.00 |  |  |  |  |
| ENGL | 102 | USC Columbia | UG | Rhetoric and Composition | | A | 3.000 | 12.00 |  |  |  |  |
| MATH | 241 | USC Columbia | UG | Vector Calculus | | A | 3.000 | 12.00 |  |  |  |  |
| PEDU | 180 | USC Columbia | UG | Archery | | A | 1.000 | 4.00 |  |  |  |  |
| **Term Totals (Undergraduate)** | | | | | | | | | | | |  |
|  | | | | | **Attempt Hours** | **Passed Hours** | **Earned Hours** | **GPA Hours** | **Quality Points** | **GPA** | |  |
| **Current Term:** | | | | | 15.000 | 15.000 | 15.000 | 15.000 | 59.50 | 3.967 | |  |
| **Cumulative:** | | | | | 30.000 | 30.000 | 30.000 | 30.000 | 119.50 | 3.983 | |  |
|  | | | | | | | | | | |  |  |
| |  | | --- | | Unofficial Transcript | | | | |  |  |  |  |  |  |  |  |  |
| **TRANSCRIPT TOTALS (UNDERGRADUATE)**[**-Top-**](https://ssb.onecarolina.sc.edu/BANP/bwskotrn.P_ViewTran#top) | | | | | | | | | | |  |  |
|  | | | | **Attempt Hours** | **Passed Hours** | **Earned Hours** | **GPA Hours** | **Quality Points** | **GPA** | |  |  |
| **Total Institution:** | | | | 30.000 | 30.000 | 30.000 | 30.000 | 119.50 | 3.983 | |  |  |
| **Total Transfer:** | | | | 0.000 | 0.000 | 11.000 | 0.000 | 0.00 | 0.000 | |  |  |
| **Overall:** | | | | 30.000 | 30.000 | 41.000 | 30.000 | 119.50 | 3.983 | |  |  |
|  | | | | | | | | | | |  |  |
| |  | | --- | | Unofficial Transcript | | | | |  |  |  |  |  |  |  |  |  |
| **COURSES IN PROGRESS**[**-Top-**](https://ssb.onecarolina.sc.edu/BANP/bwskotrn.P_ViewTran#top) | | | | | | | | | | |  |  |
| **Term: Fall 2016** | | | | | | | | | | |  |  |
| **College:** | | | | College of Arts and Sciences | | | | | | |  |  |
| **Major:** | | | | Mathematics | | | | | | |  |  |
| **Student Type:** | | | | Continuing | | | | | | |  |  |
| **Subject** | **Course** | **Campus** | **Level** | **Title** | | | **Credit Hours** | | **Start and End Dates** | |  |  |
| CSCE | 146 | USC Columbia | UG | Algorithmic Design II | | | 4.000 | |  | |  |  |
| HIST | 111 | USC Columbia | UG | United States History to 1865 | | | 3.000 | |  | |  |  |
| MATH | 300 | USC Columbia | UG | Transition to Advanced Mathematics | | | 3.000 | |  | |  |  |
| MATH | 499 | USC Columbia | UG | Undergraduate Research | | | 1.000 | |  | |  |  |
| PEDU | 136 | USC Columbia | UG | Yoga | | | 1.000 | |  | |  |  |
| STAT | 509 | USC Columbia | UG | Statistics for Engineers | | | 3.000 | |  | |  |  |
|  | | | | | | | | | | |  |  |
| |  | | --- | | Unofficial Transcript | | | | |  |  |  |  |  |  |  |  |  |