MINITERM 102-007, Spring 2023

Experimental Mathematics and Symbolic Computation

Course type: Signature work mini-term course, Spring 2023, March 13-16

Instructor: Lin Jiu, Lecturer in Mathematics

Course Description

It is well-known that computer programming has been largely applied in computations of mathematics, especially in numerical analysis, simulation, modeling, etc. Meanwhile, theoretic mathematics also involves coding, software, and algorithms. For example, the four-color theorem states that any map in a plane can be colored using four colors in such a way that regions sharing a common boundary (other than a single point) do not share the same color; and the original proof is computer-based, which is infeasible for a human to check by hand. The course aims to develop ideas for signature work, mainly for students majoring in mathematics, computer science, and data science, and students from other majors are also welcome to explore. We shall take the tour to certain topics in symbolic computation and experimental mathematics, beginning with basic examples of WZ-method, generating functions, and symbolic integration. Besides mini-lectures, discussions, readings, and coding homework, we will also invite a senior researcher (TBC) in this area to give a (possibly online) presentation.

Prerequisites:

- MATH201 Multivariable Calculus,
- MATH202 Linear Algebra,
- MATH205 Probability and Statistics or MATH 203 Advance Calculus or COMPSCI203 Discrete Math for Computer Science. (Namely the topic of Sequence and Series)

Learning objectives:

1. Analyze basic examples in symbolic computation, e.g., hypergeometric identities, WZ-method, holonomic sequences, etc.

2. Manipulate Mathematica, including basic commands, Wolfram documentation, and well-established packages

3. Discuss and generate ideas on (potential) signature work by combining skills and strategies from the course and basic knowledge from previous math courses, e.g., MATH201/202/203/205/206.

Course Policies

Academic Integrity:

As a student, you should abide by the academic honesty standard of Duke Kunshan University. Its Community Standard states: "Duke Kunshan University is a community comprised of individuals from diverse cultures and backgrounds. We are dedicated to scholarship, leadership, and service and the principles of honesty, fairness, respect, and accountability. Members of this community commit to reflecting upon and upholding these principles in all academic and non-academic endeavors and to protecting and promoting a culture of integrity and trust."

Academic Policy & Procedures:

You are responsible for knowing and adhering to academic policy and procedures as published in University Bulletin and Student Handbook. Please note that an incident of behavioral infraction or academic dishonesty (cheating on a test, plagiarizing, etc.) will result in immediate action from me, in consultation with university administration (e.g., Dean of Undergraduate Studies, Student Conduct, Academic Advising). Please visit the Undergraduate Studies website for additional guidance related to academic policy and procedures.

Academic Disruptive Behavior and Community Standard:

Please avoid all forms of disruptive behavior, including but not limited to verbal or physical threats, repeated obscenities, unreasonable interference with class discussion, making/receiving personal phone calls, text messages or pages during class, excessive tardiness, leaving and entering class frequently without notice of illness or other extenuating circumstances, and persisting in disruptive personal conversations with other class members. Please put your cell phone on silent mode during class. If you choose to avoid adhering to these standards, I will consult with the university administration (e.g., Dean of Undergraduate Studies, Student Conduct, Academic Advising).

Academic Accommodations:

If you need to request an accommodation for a disability, you need a signed accommodation plan from Campus Health Services, and you need to provide a copy of that plan to me. Visit the Office of Student Affairs website for additional information and instruction related to accommodations.

Course expectations and remote access:

The course is not graded; participants must attend all learning activities and contribute to student presentations. Collaboration is actively encouraged. Remote access will be provided through Zoom and Sakai as usual, though synchronous participation is expected.

Materials/Readings

1. Required free textbook: M. Petkovsek, H S. Wilf, and D. Zeilberger, *A=B*, A. K. Peters/CRC Press 1997. Online version: https://www2.math.upenn.edu/~wilf/AeqB.html (already uploaded to Sakai)

2. Elective reading

(1) M. Kauers and P. Paule, *The Concrete Tetrahedron: Symbolic Sums, Recurrence Equations, Generating Functions, Asymptotic Estimates*, Springer-Verlag, Vienna, 2011.

(2) Additional research papers to be discussed in this course will be selected based on student interest.

Active and Creative Learning Strategies

Students will attend lectures, discussions, and tutorials in the morning; in the afternoon, students' tasks are to read and discuss, and finish a short (half-page long) report or program (constructing 1 or 2 functions with examples) due at the beginning of the evening session. For each day's evening, there will be a one-hour activity that includes: a tutorial, discussion, talk, and the final presentation on the last day.

Schedule and Activities

	03/13	03/14	03/15	03/16
9:00-10:30	Lecture 1 What is experimental mathematics? Examples of experimental mathematics	Lecture 2 Computer Algebra: WZ-method on proving combinatorial identities	Lecture 3 Generating Functions of Sequences	Lecture 4 Random Walks and Numbers: Identities and the Normal Number
10:30--11:00	Discussion: your plan for your SW project	Discussion: Why do we need computer for this proof?	Discussion: What is a closed-form?	Discussion: How to visualize a number
11:00--12:00	Tutorial session: Mathematica on basic commands	Tutorial session: Demo for Mathematica package: fastZeil	Tutorial session: Demo for Mathematica package: generatingfunctions	Further Discussion: Developing signature work ideas
14:00--17:00	Afternoon Task: (1) Installation of Mathematica (2) Review basic tutorials on Mathematica (3) Reading: 3D plot and visualize your favorite function	Afternoon Task: (1) Download and use the package (2) More example. (3) Find examples that the algorithm fails with explanation	Afternoon Task: (1) Reading: Holonomic sequences: (p-finite, C-finite sequences) (2) Advanced topics (elective) Ore-algebra (3) Package usage	Afternoon Task: (1) 14:00--15:00: Presentation Preparation; and Developing signature work ideas (2) 15:00--16:00: Students' presentation

				and final discussion
17:00--18:00	Tutorial session: Animation in Mathematica	Discussion: Your plan for SW project.	Dr. Christoph Koutschan's talk	

Assignments

1. Each afternoon, students will fulfill the reading and discussion tasks based on the lecture in the morning. A short report is due at 20:00 on the first three days.

2. For the whole course, there are three discussion sessions on generating SW projects, for which the final idea will be presented on Day 4

3. No homework after the evening session.