MATH299M/CMSC389W
Visualization through Mathematica
Fall 2019   1 Credit   STICs course

Administrative
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Course Website
http://www.cs.umd.edu/class/fall2019/cmsc389w/
This course will also use an ELMS page

Overview
This course is designed to teach how to use the most common and useful features of Wolfram Mathematica, an extremely powerful technical computing system that can be used to model a wide range of problems. Students will also learn important techniques and styles that will equip them with a profound mastery of Mathematica. Plotting functions in several ways, making models that can be manipulated in real time by the user, and efficiently computing solutions to complicated equations are among the things we'll cover. We'll use these skills to model various structures in math, computer science and physics, and for the final project every student will pick something relevant to their major (or interest otherwise) to model, whether that be in physics, math, engineering, economics, or anything else mathematical in nature. Over the course of learning these tools students will encounter profound examples of what Mathematica can do, seeing first-hand that creating models that can be manipulated in real time helps greatly in understanding the underlying symmetries and properties of a problem.

Class Time
Fridays 2-2:50pm in EGR 0135

Course Materials
The text for this course will be a series of Mathematica notebooks that will be released weekly, they will be interactive files that define the tools we will be learning that week. Mathematica has excellent online documentation: http://reference.wolfram.com/language/ As a UMD student you have a free subscription to Wolfram Mathematica that you can download from TERPware: (https://terpware.umd.edu/Windows/title/1837 https://terpware.umd.edu/Mac/title/1837, https://terpware.umd.edu/Linux/title/1837) IMPORTANT: PLEASE DOWNLOAD VERSION 12

Grading
Weekly Models	40%	10 of the assigned 18 must be completed (details below)
Project 1	10%	
Project 2	10%	
Final Project	35%	
Attendance	5%	

… < 80 <= B- < 83 <= B < 87 <= B+ < 90 <= A- < 93 <= A < 95 <= A+
Note: To receive an A+ in the course, the student must score >= 95% as well as participate in the final presentation (details below).
There will also be extra credit assignments.

Weekly Models
The Weekly Models will be assigned on Mondays and due two weeks later, again on Monday, at 11:59pm, with a late deadline of Tuesday at 11:59pm. All assignments will be submitted as a .nb file through ELMS. Students are required to complete a total of 10 of these assignments according to the breakdown below:

      5/6 assignments from Weeks 1-6 – Introduction (C1, C2, C3, C4, C5, C6)
      3/6 assignments from Weeks 7-9 – Plotting (C7.1, C7.2, C8.1, C8.2, C9.1, C9.2)
      2/6 assignments from Weeks 10-15 – Advanced Topics (C10, C11, C12, C13, C14, C15)

If you complete more assignments from a section than necessary, your grade will be computed by taking the best scores of those assignments, and the extra scores can replace scores from the previous section if they are higher.
The rubric for the Weekly Models is as follows:

      50% - Properly uses the Mathematica tools taught that week
      30% - Model is instructive and insightful into the mathematics being modeled
      10% - Style, code tidiness, organization, explanation
      10% - Awesomeness – "Wow factor"

The best 3 submissions for each assignment will earn 105%, 107%, and 110% - a little competition each week ☺
The assignment prompts will in general be somewhat open-ended. I will ask to see something visualized, and it will be up to you what it exactly looks like and how it is implemented!

Projects
The two projects will be given after the first and second months of class, and for each you will have until the next project is assigned to complete them. Since students will be coming from different backgrounds, for Project 2 there are three options, Project 2a, 2b, and 2c, in the fields of vector calculus, linear algebra, and harmonic analysis, respectively, of which only one needs to be completed. If you have not taken or are enrolled in any 200 level math course, we will assign you an alternate project at the Calculus II level, namely, Project 2d on surfaces of revolution.

Final Project
The last month students will be working on their Final Project. Each student will have their own topic of choice (I'll help you pick something that will be cool to model and relevant to your interests!). During our final exam slot (time to be determined) instead of taking a final exam, we will be doing short presentations of volunteers' Final Projects! Volunteering to present will give you a 1% boost to your final grade in the class, and is the only way to earn an A+, that is, if you have >= 95% grade in the class but you choose not to give a final presentation, you will earn an A on your transcript (which is weighted as a 4.0 just like the A+, but the A+ looks cooler B)).

Attendance
Lectures are the lifeblood of *Visualization Through Mathematica* – your attendance is important for your own enrichment as well as because your participation will make the

course richer for everyone else as well ☺ If you must miss class for some reason send us an email ahead of time and we'll pardon your absence. There will be several participation quizzes on ELMS throughout the semester, the lowest three scores will be dropped.

Collaboration
Students are allowed to work together on all assignments except the Final Project. Each student must submit unique code for each assignment. If you copy other students' code all semester then on the Final Project, which will be *unique for each student*, you'll have a hard time. At the bottom of each assignment you should list the names of the students you collaborated with.

Schedule (Subject to change)

Week 1	**Introduction and Basics: Variables, Lists, Functions, Manipulate** Model C1: Investigating Infinite Sums Model H1: Asymptotic Complexity Exposition
Week 2	**Basics II: Defining Functions, Implicit Functions, Table, Map** Model C2: Converting Between Rectangular and Polar Coordinates Model H2: Convergence of Fibonacci Sequence Ratio
Week 3	**Plotting I: Plot, Options, and Manipulate controls** Model C3: Manipulating Coefficients of Polynomials Model H3: Constructive/Destructive Interference with Sine Waves
Week 4	**Computation: Solve, Limit, Derivative, Integral, Simplify, Expand, Numeric** Model C4: Graphing first N Derivatives of a Function Model H4: Newton-Raphson Method Project 1: Visualizing Taylor Approximations
Week 5	**CS-Style Scripting: Conditionals, Loops, Block, Module** Model C5: Merge Sort Model H5: Gaussian Row Reduction
Week 6	**Graphics: Graphics, Points, Lines, Shapes, Show, GraphicsGrid, Graphics3D** Model C6: Geometric Circle Area Proof Model H6: Visual Proof of the Baudhayana Theorem
Week 7	**Plotting II: RegionPlot, ContourPlot, DensityPlot** Model C7: Radius of Convergence of the Complex Geometric Series Model H7.1: Integral of a Function as Area under a Curve Model H7.2: Gravitational Field populated with several bodies
Week 8	**Plotting III: PolarPlot, ParametricPlot** Model C8.1: Visual Proof of the Pythagorean Identity $Sin^2+Cos^2=1$ Model C8.2: Visualizing Homotopic Equivalence Model H8.1: Visualizing Trig Functions on the Complex Plane Model H8.2: Visualizing Integrals on Washers and Wedges Project 2a: Partial Derivatives and Gradient Visualization Project 2b: Dot Product and Cross product Visualization Project 2c: Fourier Analysis Visualization Project 2d: Surfaces of Revolution
Week 9	**Plotting IV: Plot3D, ContourPlot3D, ParametricPlot3D** Model C9.1: Investigating the RGB Color Model Model C9.2: Visualizing Non-Orientable Surfaces

	Model H9.1: Visualizing Trig Functions on the Complex Plane (Part II) **Model H9.2: Drawing Conic Sections as Level Sets of Paraboloids**
Week 10	**Manipulate II: Locators, LocatorAutoCreate, Intro. to Dynamic** **Model C10.1: Interactive Polygon** **Model C10.2: Visualizing Linear Transformations of R^2** **Model H10.1: Poles of Complex Functions**
Week 11	**Development: Import, Export, Packages, Initialization Cells, .m, .mx** **Model C11.1: Cardinal Numbers Package** **Model C11.2: Snapshot Export Widget** **Model H11: Create Bases Package** **Model Ex2: The Mandelbrot Set** **Choosing Final Projects!**
Week 12	**Parallelization: Parallelize, Kernels, Timing, Memory** **Model C12: Parallelizing Finding Glitch Primes** **Model H12: Parallelization Super-Computing Competition!**
Week 13	**Advanced Dynamic: Proper use of Dynamic and Dynamic Module** **Model C13.1: Modeling Particles in a Box** **Model C13.2: Pong** **Model H13: Writing Manipulate in Dynamic**
Week 14	**Precomputing: The Art of Pre-Computation** **Model H14: Precomputation Update to Past Assignment**
Week 15 **Last Class of Semester**	**Evaluation Control: Evaluate, Hold, Tuning and Debugging** **Model C15: Evaluation Control in Model with Change of Variables** **Model H15: Stable Algorithm for Solving Linear Systems**
Final Exam Week	**Showing off the Power of Mathematica through Examples:** **Fractals, Relativistic Beaming, Barn-Ladder Paradox, Möbius Transformations, Dynamical Systems, Chaos, Hyperbolic Geometry, Interpolation Techniques, Geometric Constructions, and more**

In Black is the topic of the week (the tools we'll be learning)
In Green are the in-class example(s) that we'll look at
In Blue is the homework assigned that day which will be due the next week
In Pink are when the Projects are assigned

Final Project ideas:
- **Visualizing Homotopic Equivalence**
- **Constructions from Euclid's Elements**
- **3D Electron Orbits using the Wave Function**
- **Create a Complex Variables Package**
- **Stable Two-Body Orbits**
- **Cryptocurrency Momentum Strategy Stock Analysis**
- **Evolution of Heat in 3D-Space by the Heat Equation**
- **Visual Proof of Kepler's Laws of Planetary Motion**
- **Electromagnetic Field Lines around a Dipole**
- **Visualizing Fractional Derivatives**
- **Hybrid Plots Package: ParametricContourPlot3D, GraphicsPlot, PlotND, ...**
- **Constructing Conic Sections**
- **Zooming in on the Mandelbrot Set**

- **Visualizing Four-Dimensional Surfaces**
- **Mathematics of Auditory Illusions**
- **Simple Harmonic Motion**
- …

Course Policies
The standard course policies apply: http://ugst.umd.edu/courserelatedpolicies.html
Students must also fill out the Usage Agreement (uploaded on ELMS) regarding distribution of course materials.

GitHub
If you would like to see cool things Ajeet (Founder of this course) made in Mathematica, here is the link to his GitHub repository:
https://github.com/Eigenajeet/MathematicaPortfolio

(Syllabus is subject to change)