Mathematical & Computational Biology Preparatory Workshop

Syllabus Schedule

Workshop will consist of tutorials and extensive practicals with interaction/supervision by faculty and TAs.
Modern laptop computer (PC or Mac) required.

Day 1 (Professor Fred Wan)
- Basic Mathematica operations: addition, subtraction, multiplication, division, exponentiation
- Elementary functions: powers, roots, logarithm, trigonometric functions, absolute value, etc.
- Plotting in two and three dimensions
- Basic rules: Capital Letters (Limit) = Function; Brackets ([ ]) = Calculate; Braces ({ }) = List or Range; etc.
- Loops, simplify, logic operations, random numbers generation, tables, etc.
- Single linear and nonlinear equation: symbolic and numerical solutions
- Linear systems: matrix operations, inverse, symbolic and numerical solutions, LU decomposition, back substitution
- Homogeneous linear systems and matrix eigenvalue problems: eigenvalues and characteristic equation, eigenvectors
- Matrix diagonalization, Jordan form

Day 2 (Professor Fred Wan)
- Calculus through Mathematica: limit of functions, derivatives, symbolic and numerical, rules of differentiation, composite functions.
- Rolle's theorem, mean value theorem
- Stationary points of functions, vanishing of first derivative, extremum, inflection by second derivative
- Integration: Riemann sums, definite integrals, indefinite integrals, fundamental theorem of calculus, symbolic and numerical evaluation
- Useful rules of integration.
- Intermediate value theorem, extended mean value theorem
- Taylor's theorem and Taylor's series, approximating functions by truncation of their Taylor series, graphing truncated series
- Single ordinary differential equation, general solution, initial value problems (IVP), analytical methods, numerical solutions by Simple Euler,
- Improved Euler, 4th order Runge-Kutta
- Solution singularities for linear ODE; estimating a singularity of nonlinear ODE, accurate determination of a solution singularity for nonlinear ODE

Day 3 (Professor Fred Wan)
- Functions of several variables, partial derivatives, stationary points and extrema of functions of several variables
- Taylor's theorem and Taylor's series
- Multiple integration, iterated and double (multiple) integrals
- Vector algebra and calculus, gradient, divergence and curl, vector integration (divergence theorem, Stokes' theorem, etc.)
- Advanced topics via electronic tutorial by Professor Peter Taborek

Day 4 (Professor John Lowengrub)
- Partial differential equations: analytical and numerical methods of solution by Mathematica and MATLAB.

Day 5 & 6 (Assist. Prof. Xiaohui Xie)
- Biostatistics – overview focusing on stochastic and probabilistic methods for systems biology.
- Specific topics will include: linear models, linear regression, principle component analysis, support vector machines, bayesian networks, stochastic processes, chemical reaction models, and diffusion approximation.
- MATLAB implementation