COMP 4420 – Advanced Analysis and Design of Algorithms

Calendar Description: Algorithm design with emphasis on formal techniques in analysis and proof of correctness. Computational geometry, pattern matching, scheduling, numeric algorithms, probabilistic algorithms, approximation algorithms and other topics. **Prerequisites**: COMP 3170 and [one of STAT 1150, STAT 2000 (B), STAT 2001 (B), STAT 2220, or PHYS 2496].

Outline

1) Mathematics for the Analysis of Algorithms (3 weeks)
   Generating functions, asymptotic estimates, binomial coefficients, Fibonacci numbers, Harmonic series, logs, Euler's summation formula, Euler's constant, and Stirling's formula.
2) Introduction to Computational Geometry (3 weeks)
   Polygons in the plane, Convex regions in the plane, 2D Convex hull algorithms -- Graham's algorithm, giftwrapping, the incremental algorithm, etc., Convex linear combinations, the use of randomized algorithms, 3D Convex Hulls -- convex polyhedra in 3 and more dimensions, the incremental algorithm for 3D Convex Hulls, duality, intersection of half-spaces
3) Polyhedra (1 ½ weeks)
   Polyhedra in 3 and 4 dimensions, the platonic polyhedra, the regular 4D polyhedra, algorithms for constructing and displaying polyhedra, applications to chemistry -- fullerenes.
4) Computability of the Real Numbers (2 weeks)
   The Mandelbrot set, dynamical systems, iterations in the complex plane, Julia sets, algorithms for constructing fractals and their limitations, algorithms for drawing fractalized objects in 2 and 3 dimensions.
5) Introduction to Computability (1 ½ weeks)
   Post's Correspondence Problem, Thue systems, the word problem, computability, various undecidable problems.
6) Introduction to Quantum Computing (2 weeks)
   The 2-slit experiment, deterministic vs. non-deterministic computing, Schrodinger's equation, the wave function, the qubit, ion-cages as qubits, quantum gates, unitary transformations, measurement of a qubit -- collapse of the wave function, the Hadamard gate and other quantum gates, entanglement, the no-cloning theorem, quantum circuits for integer addition.

Optional References: Mathematics for the Analysis of Algorithms (Knuth), Computational Geometry in C (O'Rourke), Regular Polyhedra (Coxeter), Chaos and Fractals (Jurgens and Peitgen), Computing over the Reals: Foundations for Scientific Computing (Braverman and Stephen Cook - article in AMS Notices, 2006), Computability (Salomaa), Computability (Aho, Hopcroft, Ullman), Quantum Computing (Gruska)