COURSE NUMBER/TITLE: MSCS-492 Mathematical & Computational Foundations of Bioinformatics

CREDITS: 3

COURSE DESCRIPTION: In depth examination of different types of algorithms employed in bioinformatics, their mathematical foundations, and software implementation. Topics in mapping DNA, sequencing DNA, comparing sequences, predicting genes, finding signals, identifying proteins, repeat analysis, DNA arrays, genome rearrangements, molecular evolution, phylogenetics, machine learning, systems biology and computational biology. Prerequisite: Senior level or higher; Applied Math & Computer Science majors only.

TEXTBOOK: *An Introduction to Bioinformatics Algorithms*, 1st Ed. by Jones & Pevzner (adopted Fall 2007)

COURSE OBJECTIVES:
This course will enable the students to:
1. Analyze the mathematical, statistical and computational issues underlying bioinformatics problems.
2. Apply mathematical, computational and statistical techniques, as well as understand the theories that support the techniques.
3. Appreciate how bioinformatics serves the life sciences.
4. Explain the different algorithmic approaches to solving bioinformatics problems.
5. Evaluate the capabilities and limitations of existing bioinformatics tools.
6. Differentiate the nature of information involved in bioinformatics and how it is represented, including databases and data structures.
7. Work effectively in a team to produce at least a partial solution to a currently unsolved problem in bioinformatics.
8. Create and deliver an effective presentation of the final course project.

COURSE OUTLINE:
I. Bioinformatics Algorithms and Programming (objectives 1-6)
   A. Algorithms and Complexity
   B. Software Tools and Languages for Bioinformatics Programming. (objective 7)
   C. Mapping DNA and Finding Signals
      a) Exhaustive Search
      b) Greedy Algorithms
      c) Hidden Markov Models
      d) Randomized Algorithms
   D. Genome Rearrangements
   E. Comparing Sequences and Gene Prediction
      a) Dynamic Programming Algorithms
      b) Divide and Conquer Algorithms
      c) Graph Algorithms
d) Combinatorial Pattern Matching
F. Sequencing DNA, Identifying Proteins and DNA Arrays
G. Repeat Analysis
H. Molecular Evolution and Phylogenetics
   a) Molecular Evolution Models
   b) Clustering Methods
      i. UPGMA (Unweighted Pair Group Method with Arithmetic Mean)
      ii. Neighbor Joining
   c) Cladistic Methods
      i. Maximum Parsimony
      ii. Maximum Likelihood
      iii. Bootstrapping
I. Applications of Bioinformatics to current Research (objectives 8,9)
II. Selected Topics as Time and Interest Permits (objectives 1-6)
   A. Machine Learning and Neural Networks
   B. Systems Biology and Metabolic Pathways
      a) Transcription Networks
      b) Autoregulation
      c) Feed Forward Loops
      d) Temporal Programs and Global Structure of Transcription Networks
   C. Clinical Bioinformatics (objective 4)
      a) Drug Discovery and Development
      b) Understanding Diseases and their Diagnosis
   D. Structural Bioinformatics
      a) Protein Structure and Prediction
   E. Data Integration and Bioinformatics Standards
   F. Computational Biology and Algebraic Statistics