Minor Program in Computational Science
Competency/Topic Overview
Area 1: Simulation and Modeling

Competency/Descriptors
Explain the role of modeling in science and engineering **Descriptors:** Discuss the importance of modeling to science and engineering Discuss the history and need for modeling Discuss the cost effectiveness of modeling Discuss the time-effect of modeling (e.g. the ability to predict the weather) Define the terms associated with modeling to science and engineering List questions that would check/validate model results Describe future trends and issues in science and engineering Identify specific industry related examples of modeling in engineering (e.g., Battelle; P&G, material science, manufacturing, bioscience, etc.) Discuss application across various industries (e.g., economics, health, etc.)
Analyze modeling and simulation in computational science **Descriptors:** Identify different types of models and simulations Describe a model in terms of iterative process, linking physical and virtual worlds and the science of prediction Explain the use of models and simulation in hypothesis testing (e.g. scientific method)
Create a conceptual model **Descriptors:** Illustrate a conceptual modeling process through examples Identify the key parameters of the model Estimate model outcomes Utilize modeling software and/or spreadsheets to implement model algebraic equations (e.g. Vensim, Excel, MATLAB, Mathematica) Construct a simple computer visualization of the model results (e.g. infectious disease model, traffic flow, etc.) Validate the model with data Discuss model quality and the sources of errors
Examine various mathematical representations of functions **Descriptors:** Describe linear functions Define non-linear functions (e.g., polynomials, exponential, periodic, parameterized, etc.) Visualize functions utilizing software (e.g. Excel, Function flyer, etc.) Determine appropriate functional form to fit the data Demonstrate essential mathematical concepts related to modeling and simulation
Analyze issues in accuracy and precision **Descriptors:** Describe various types of numerical and experimental errors Explain the concept of systematic errors Explain the concept of data dependent errors Illustrate calculation and measurement accuracy Identify sources of errors in modeling and approaches to checking whether model results are reasonable

Understand discrete and difference-based computer models
Descriptors:
Explain the transition of a continuous function to its discrete computer representation
Represent "rate of change" using finite differences
Cite examples of finite differences
Explain derivatives and how they relate to model implementation on a computer
Write pseudo-code for finite difference modeling

Demonstrate computational programming utilizing a higher level language or modeling tool (e.g. Maple, MATLAB™, Mathematica, other)
Descriptors:
Describe the system syntax (e.g., menus, toolbars, etc.)
Define elementary representations, functions, matrices – arrays, script files, etc.
Explain programming and scripting processes (e.g., relational operations, logical operations, condition statements, loops, debugging programs, etc.)
Create tabular and visual outputs (e.g., 2-D and 3-D subplots)
Translate the conceptual models to run with this system and assess the model results (e.g. traffic flow and/or "spread of infectious disease")
Illustrate other people's models utilizing the modeling program

Assess computational models
Descriptors:
Assess problems with algorithms and computer accuracy
Discuss techniques and standards for reviewing models
Verify and validate the model
Discuss the differences between the predicted outcomes of the model and the computed outcomes and relevance to the problem
Discuss the suitability and limits of the model to address the problem for which the model was designed

Build event-based models
Descriptors:
Describe event-based modeling (e.g. SIMULINK™; Extend, ARENA)
Run existing models
Translate conceptual models (e.g., traffic flow utilizing SIMULINK™)

Complete a team-based, real-world model project
Descriptors:
Identify a problem, create mathematical model and translate to computational modeling
Organize and present project proposal
Document model development and implementation
Collaborate with team members to complete the project

Demonstrate technical communication
Descriptors:
Demonstrate technical writing skills in the comprehensive report
Demonstrate verbal communication skills in an oral presentation
Create and present visual representation of model and results
Address all components of a comprehensive technical report
Respond to peer review