ISAT 341: Modeling and Simulation (Sec 1, 2, & 3)
Spring 2014

COURSE AND INSTRUCTOR INFORMATION

Meeting Times:	**Guided Session**: W 5:00pm-6:15pm in HHS 2210
	Open Lab:
	M 9am to 11am in ISAT/CS 343
	M 8pm-Midnight in ISAT/CS 343, 337, 336 (Hacking Session)
Instructor:	Nicole Radziwill, Ph.D., MBA
Office:	ISAT/CS 325
Phone/SMS:	703.835.6336 (SMS or Email 24/7)
Email:	nicole.radziwill@gmail.com
Office hours:	During Open Lab times, by Appointment, or Skype/gChat anytime

NATURE OF COURSE CONTENT

COURSE DESCRIPTION

Welcome to ISAT 341, an IKM course in modeling and simulation. The purpose of this class is to have an interactive dialogue on the "use of models to understand, analyze and improve systems in several areas of science and technology." Each student will focus on at least two of the following distinct approaches to modeling real-world systems, translating those models into computer simulations, and interpreting results:

- Discrete-event simulation (used to model systems in which parts, people, or other objects are *processed* in some way) using ProModel, Java, and R
- System dynamics modeling (used to model processes and systems that evolve continuously in time, including systems involving the social and environmental dynamics of public policy) using Stella
- Monte Carlo methods using Excel, @RISK, and/or R
- Agent-based modeling (ABM) using NetLogo and R
- Numerical weather prediction (1D and 2D cloud models, groundwater modeling, mesoscale and synoptic scale atmospheric modeling, global climate models)
- miscellaneous methods, e.g. graph-based modeling (e.g. social networks), simulated annealing to solve Sudoku puzzles, inventory modeling, bridge playing strategies

Computer simulation allows us to construct a computer representation of a real-world system and to experiment with the computer version so that we can understand and predict how the real-world system will behave under a variety of circumstances. Computer simulation is ideal when 1) we can't alter the real world system, but need to know how change will affect it; 2) when we have

not yet constructed the real-world system, but need to know how it will behave (or to get a better handle on its costs and benefits); or 3) when the real-world system is so complex that we can not construct and solve and an exact mathematical description of it. A simulation can be explicitly time dependent, but does not have to be. One important characteristic of a real-world system that gives simulation value added is when the system is stochastic, that is, when the system has random behavior that varies statistically, which makes the system impossible to model with equations. Another kind of system that can be modeled is one involving feedback loops and interdependencies. This kind of system can be modeled using difference or differential equations (or systems of equations), but a simulation tool can allow us to do this easily and visually. Hence, simulation is particularly valuable for problems that are not amenable to an exact mathematical description (they are too complex), for problems that involve randomness (Monte Carlo and discrete event systems), and for dynamic situations with interdependencies and feedback (system dynamics). This course employs some labs, exercises and other materials developed by Dr. Anne Henriksen and Dr. Mike Deaton.

The goal of this course is to make you a discerning and knowledgeable user of simulation as a tool for solving some kinds of real-world problems. At the end of this course, you will understand the principles underlying these three kinds of simulation and when each is appropriate to use.

COURSE STYLE & DELIVERY

This course implements the **10 Principles of the Burning Mind Project** as its core value system. (http://www.burningmindproject.org/the-ten-principles/) As a result, the course is somewhat self-directed, blended (integrating online and in-class components), gift-oriented, and synchronously coordinated with two other courses: ISAT 252 (Programming & Problem Solving w/Benton) and HON 300/ISAT 680 (Quality & Process Improvement in Action w/Radziwill and Simmons).

- **Self-Directed**: You will prepare a work plan for the semester and work towards successfully achieving many of the activities you attempt. You are not required to complete all activities you attempt. You can work individually or in teams, however, you must work as part of a team for Development Cycle 4.
- **Blended**: Some of the work can be done online, at your leisure (for example, any of the COMET modules for exploring Numerical Weather Prediction). There will be ample open lab time, with instructor guidance, provided for you to complete lab exercises and extend those lab exercises to create new explorations and new recipes.
- **Gift-Oriented**: In many classes, you may ask "what can I *get* out of taking this class?" However, in this course, we want you to ask the question "what can I *give* to others as a result of my participation in this class?" *Individual gifts* are an important component. As you explore the simulation topics, we request that you identify things you are good at and can contribute to a larger, team project. Put together a one-page poster pop for each individual gift that you think would be useful to contribute to a larger group project. Then, your classmates can find you if they need your skills to build out a particular solution.
- **Synchronously Coordinated**: The course schedule for 341 has been coordinated with the schedules for ISAT 252 (Benton's sections) and HON 300/ISAT 680. We encourage you to partner with programming teams in ISAT 252 to create mobile, online, or desktop

applications that leverage simulations and/or simulation results. We also encourage you to partner with HON 300/ISAT 680 project teams to construct models and execute simulations that will help them satisfy the needs of their community agency and small-business clients.

The course consists of one guided ("lecture") session and one open laboratory portion per week.

SCHEDULE

We will do the following modules together in January:

- Random Number Generation
- Distribution Fitting
- Methodologies and Output Analysis

Then, you and your team will choose two of the following to work on in February and March:

- Discrete Event Simulation
- System Dynamics
- Monte Carlo Simulation
- Numerical Weather Prediction
- Agent-Based Modeling (ABM)
- Mixed Models (using multiple approaches on the same problem)

You will finalize or complete a project/presentation to share during finals week in May.

GOALS OF THE COURSE

By the end of this course, you will learn some of the basic concepts behind both discrete event and system dynamics simulation models. You will also learn how to analyze some real-life systems by building and using models of each type. The learning goals for this course are listed below. You will:

1. ***Understand*** and be able to use the basic terminology used by practitioners in the computer simulation field such as:
    - Problem articulation
    - Formulation of research questions and hypotheses
    - Model building, validation and verification
    - Random number generation
    - System bottlenecks
    - Entities, servers, processing steps, processing logic, flows, reservoirs, and converters
    - Balancing and reinforcing feedback
    - Causal loop diagrams, stocks and flows, policy resistance, unintended consequences
2. ***Describe the benefits and the limitations*** of computer simulation models
3. ***Characterize and analyze the structure*** of real-life systems and use that structure to explain the behavior of the system

4. Use existing models to ***perform "experiments"*** and thereby identify ways to improve system performance
5. Learn how to ***use at least two*** different computer-based simulation tools (e.g. ProModel®, Stella®, @RISK, R) to build computer models of real life systems and to use those models to analyze the systems.
6. Describe and ***apply a systematic process*** for developing and using simulation models

METHODS OF EVALUATION

GRADING

The goal of this course is to *produce artifacts* that demonstrate your understanding of the topics that we cover, and that *provide value* to real clients and/or real people (including your instructors, the students within your learning community, and students who will participate in future learning communities that want to investigate the topics in ISAT 341).

Grading is based on *accrued points* for completing various labs, exams, and projects, to the satisfaction of the instructor and/or instructor-designated proxies. You get as many chances as you like **within one development cycle** to continually improve the quality of your work, but points can only be accrued for successful completion of a particular activity or artifact.

Typically, assignments will be reviewed by multiple people including the instructor, other instructors, the TAs, or students from other coordinated courses who are acting as clients for your projects. Successfully completed Level 1 activities accrue 1 point, successfully completed Level 2 activities accrue 2 points, and successfully completed Level 3 activities accrue 3 points.

For example, completing a project AND using the work from that project to write a new lab for future students would accrue 6 points.

Grading Scale: 40+ accrued points is an A, 30-39 is a B, 20-29 is a C, 10-19 is a D, below 10 is an F.

GRADING

The goal of this course is to *produce artifacts* that demonstrate your understanding of the topics that we cover, and that *provide value* to real clients and/or real people (including your instructors, the students within your learning community, and students who will participate in future learning communities by enrolling in ISAT 344).

Grading is based on *accrued points* for completing various labs, exams, and projects, to the satisfaction of the instructor and/or instructor-designated proxies. You get as many chances as you like within one development cycle to continually improve the quality of your work, but points can only be accrued for successful completion of a particular activity or artifact. There are 90+ available points outlined below, and items in italics are the 11 points we will complete together during the first three weeks of the course.

1 Point Each	2 Points Each	3 Points Each	4 Points Each
1. Methodology Quiz *2. Intro to Simulation & Modeling Quiz* *3. Normal CDF and PDF* *4. Triangular RNG* *5. Weibull RNG* 6. NWP - Definition Sheet 1 7. NWP - Definition Sheet 2 8. SD - each one of the 14 exercises in Martin's "Beginner Stella Models" 10. SD - Terrorism Tutorial ** Reflection/Exit Interview is also one point	*11. Exponential RNG* *12. Distribution Fitting w/ Stat Fit* *13. Output Analysis w/Conf Intervals* 14. DES - Manual Simulation 15. DES - Manual Simulation w/Java 16. DES - ProModel Tutorial 17. NWP - Definition Sheet 3 18. ABM - NetLogo Exploration 19. ABM - Conway's Game of Life in R 20. Complete any new lab created by fellow students and approved by instructor 21. **Present Group Project at end of semester (*)**	21. DES - Multiple Products 22. DES - MSMQ 23. All 6 examples from "Stella Models for HS" 24. Any one "Mixed Methods" labs where you can compare modeling results from multiple approaches, e.g. the SIR labs 25. Create New Lab 26. Exam for DES, SD, ABM, MC, and/or NWP - 85%+ on first attempt, or Oral Exam for deficiencies 27. Become "approver" for DES, SD, MC, or ABM	**28. Complete Grp Project (*) - no more than 4 on a team** 29. Teach a Class (requires completing exercises in advance, getting approved by instructor) 30. Write and submit research paper for the new JMU Research Journal (http://jmu.edu/jmurj) - WILL DOUBLE POINTS to 8 IF ACCEPTED!! The paper can (and should) be based on a project you do in this class

(*) = REQUIRED

Grading rubrics for assessment of the team projects will be issued later in the semester.

Your work plan should take into consideration:

- That all exercises, labs, and new labs **must be checked off (and points received) by the end of March**. It is important that everyone is able to relax and focus on their semester projects throughout the month of April.
- That there will be scheduled sittings for the DES, SD, ABM, and MC exams (the NWP exam is take-home). If you plan to take an exam, you should complete the preparatory exercises in advance of those exam dates.
- **That the exercises provided to you are just "starting places".** I would love to see you develop new labs this semester, or conduct real research projects that you can submit to arXiv.org and the new JMU Research Journal! Also, there are opportunities to help me with some more advanced research projects, and developing labs that I'd love to see (but that don't exist yet). These would be worth 3-8 points each depending upon how much I want to get them done. Inquire within!
- **Your points are "vested"** when you sit for the final presentations and complete a short reflection exercise and exit interview with your professor.

Grading Guidelines: 36+ accrued points is an A, 28-35 is a B, 20-27 is a C, 12-19 is a D, below 12 is F. To receive a passing grade in this course, you should successfully conduct and complete at least one simulation and modeling project of your own.

REQUIREMENTS & POLICIES

REQUIRED TEXTS and SOFTWARE

- Excerpts from *Simulation Using Promodel 3rd ed.* by Harrell, Ghosh & Bowden, McGraw-Hill, 2011; Excerpts from *Business Dynamics: Systems Thinking and Modeling for a Complex World* by J. D. Sterman, and many online textbooks and resources

- Some software is provided in the ISAT classrooms on the 3rd floor (e.g. ProModel, R); other software (e.g. @RISK) can be purchased and downloaded individually, if you choose to use it to meet the learning objectives of the course.

ADD/DROP DEADLINES

All of the dates related to adding, dropping, and withdrawing from this course are in the JMU catalog and are posted on the University Registrar's web site (http://www.jmu.edu/registrar). **YOU ARE RESPONSIBLE FOR KNOWING THESE DATES.** Professors are not required to grant grades of "WP" or "WF" after that date and I typically do not. I do not allow incompletes.

COURSE POLICIES AND PROCEDURES

Any accommodations (e.g. for sickness) must be made ahead of time with me. As long as there is a justifiable reason that I agree with, I will be as flexible as I can to help you complete the requirements for this course. The most important part is *setting my expectations effectively.*

Attendance and Participation

Attendance is, in general, required because we aim to be part of a vibrant learning community. I don't take attendance formally *but I do notice when people are missing, and your peers who need your expertise will also notice when you are missing.* The amount of understanding and flexibility you will get from me will be inversely proportional to the amount of class you miss.

Exams

Several exams will be given throughout the semester. Credit for completing the exam can be achieved in one of two ways: 1) by getting at least an 85 on the first attempt of the written exam, OR 2) by meeting with the instructor for an oral exam to remedy the deficiencies from the first attempt of the written exam.

Missed Exams

Make-up exams will not be given. There are a multitude of opportunities within this course to achieve the learning objectives so if a student is unable or unprepared to sit for an exam, he or she can choose from a suite of alternatives to demonstrate the course competencies.

Final Exam Session

Everyone is required to attend the scheduled exam session during finals week for its full duration. There will be no exceptions to this policy except in the case of dire emergency (e.g. you unexpectedly had to get your appendix out the day before and just can't show up for it).

Special Needs

If you are a student who is registered with the Office of Disabilities, I need to be given written documentation to support your situation in order to provide you with any accommodations (this is required by law). YOU are responsible for pre-arranging with me to provide accommodations (e.g., additional time for an exam). I suggest an email a few days ahead of time so that arrangements can be made. In your email, you need only say that you are contacting me to

arrange for your accommodation; you do not need to elaborate in your email. It is ALWAYS necessary to work things like this out in advance.

Honor Code

You are expected to abide by the JMU Honor Code at all times. Examples of academic dishonesty that are violations of the Honor Code include, but are not limited to, the following: turning in work under only your own name that you did not actually do completely yourself (for collaborative work, *always* list the names of your collaborators), plagiarizing other people's words or computer code (and that includes text off the Internet), receiving unauthorized help on an exam, providing unauthorized help on an exam (and that includes talking about an exam before all students have taken it), and misuse of materials that are permitted for an exam. Violations of the JMU Honor Code will be dealt with in accordance with the policy that permits professors, at their own discretion, to assess and penalize students for cheating. All incidents of academic dishonesty will be reported to the Honor Committee, according to the requirements of the university. Regarding **Working in Groups:** Be a good citizen and follow the JMU Honor Code. If you aren't sure if some type of collaboration is appropriate, please ask. You are responsible to make sure your actions are appropriate and exhibit the highest levels of integrity.

Weather

Please check the JMU cancellation policy for information about the impact of inclement weather on our class (http://www.jmu.edu/JMUpolicy/1309.shtml). Your instructor drives in from Charlottesville. If there are any issues with her commute the class will be notified by email.

Contacting the Instructor

You can contact the instructor any time (24/7) via email or SMS to 703.835.6336.