Course Syllabus

ABE 5643C- Biological Systems Modeling

Fall Semester 2019

Fall Semester: 3 credits

Lectures: Tuesdays & Thursdays 3rd Period (9:35 am – 10:25am) **Rogers 283**

Lab Period: Wednesday 8th – 10th Period (3 pm – 6 pm) **Rogers 283**

Instructors:

Dr. Greg Kiker, Professor
Dept. of Agricultural and Biological Engineering, Rogers Hall, Room 291
Phone 294-6749; E-mail **gkiker@ ufl.edu (mailto:graham@agen.ufl.edu)** ; Office Hours: By appointment

Dr. Ray Huffaker, Professor

Dept. of Agricultural and Biological Engineering, Rogers Hall, Room 281
Phone 294-6745; E-mail **rhuffaker@ufl.edu (mailto:rhuffaker@ufl.edu)** ; Office Hours: By appointment

Dr. Rafael Muñoz-Carpena, Professor

Dept. of Agricultural and Biological Engineering, Rogers Hall, Room 287
Phone 294-6747; E-mail **carpena@ufl.edu (mailto:carpena@ufl.edu)** ; Office Hours: By appointment

Pre-requisites: This course assumes no modeling experience or computer programming. Familiarity with differential equations can aid in most sections of the course.

General Description and Objectives: This course serves as an introductory graduate class for modeling biological processes and systems at a variety of scales with a special emphasis on the integration of systems description, model designs and computer code implementation. It is the first and required course of the Biological Modeling Certificate offered by ABE (**http://www.abe.ufl.edu/academics/graduate/certificate-biological-systems-modeling.shtml (http://www.abe.ufl.edu/academics/graduate/certificate-biological-systems-modeling.shtml)**) . It is the pre-requirement for the second advanced modeling course (ABE 6649C).

The course covers a core curriculum of system description techniques such as traditional systems

dynamics (Forrester) as well as more recent interdisciplinary approaches such as Soft Systems Analysis (Checkland). Systems description in words and mathematical equations are then translated into model designs through flow charts, pseudo-code, free-form languages (XML,NetLogo script or Nova script) or Unified Modeling Language (UML). Subsequently, these model designs are translated into computer code for simulation on computer platforms.

This description-to-design-to-code methodology will be emphasized throughout the semester on various semester assignments. Individual assignments can be strictly biological in nature or can combine biological, ecological, sociological and/or economic processes. An important aspect of this course is the assessment and testing of models through sensitivity analysis, validation and stability analysis. These methodologies will be highlighted in the second half of the course.

It is expected that students will have access to their own computer for this course. A laptop computer is strongly recommended for all laboratory periods so that students can use the same computer for labs as they will use in homework assignments.

Several different computer programming languages will be used in this course; Basic, Fortran, Python, NetLogo, Nova, R and Java. Other languages may be used with the permission of the instructor. Often homework assignments may include two or more languages to be used in creating solutions. This multi-platform perspective is useful in helping to determine the relative strengths and weaknesses of each language. The freeware compilers and platforms will be used to compile and execute these languages on students' own computers. While some class time will be devoted to programming design, syntax and debugging, it is expected that the student will spend additional time outside of class to learn the basic rudiments, syntax and logic of these languages.

Class Objectives/Outcomes: At the close of this course, the student will be able to:

- Conceptualize, design and implement a variety of simple and intermediate biological system models
  - Translate complex biological systems into simplified concepts/descriptions
  - Translate simplified concepts/descriptions into equations and model designs

  - Translate equations and model designs into computer source code
- Utilize Integrated Development Environments to implement and debug computer code in two or more functional programming languages and/or free-form scripts
- Develop a set of basic biological algorithms for future expansion and research
- Test and parameterize models against measured data to assess model performance and to build confidence in simulation results
- Analyze models of varying complexity for performance and stability of solutions

Course Format: Lectures are given on two days (Tuesday and Thursday, 3rd period 9:35-10:25) with a Wednesday laboratory (3 pm – 6 pm) for additional lectures, discussions, computer work or to initiate homework assignments. All topics are delivered through the Canvas software and will be introduced in the class.

Course Texts (accessed through Course Management System or UF Libraries):

- Keen, R.E. and Spain, J.D. Computer Simulation in Biology: a BASIC introduction. Wiley-Liss. ISBN: 0-471-50971-X.
- Haefner, James W. Modeling Biological Systems: Principles and Applications. Springer, 2005. (Available as an E-Book from the UF Library)
- Wallach, D., Makowski, D., Jones, J. W., and Brun, F., (2014). Working with dynamic crop models: Methods, Tools and Examples for Agriculture and Environment. Elsevier. (Available as an E-Book from the UF Library)
- Selected journal articles and web links will be provided in Canvas

Required software (all open-source/free or available via UF license):

As models are developed in a variety of platforms and styles, this course will expose students to some of the major groups of languages.

- Procedural languages
  - FORTRAN - **https://www.silverfrost.com/ (https://www.silverfrost.com/)**
  - BASIC - **http://justbasic.com/ (http://justbasic.com/)**
  - Python – **http://www.python.org (http://www.python.org)** or PyCharm: **https://www.jetbrains.com/pycharm/ (https://www.jetbrains.com/pycharm/)**
- Object-oriented design and programming

  - Unified Modeling Language (UML) Design: Astah-Community (**http://astah.net/download#community** (http://astah.net/download#community))
  - Eclipse Integrated Development Environment (**eclipse.org** (http://www.eclipse.org)) with Java (**www.java.com** (http://www.java.com))
  - IntelliJ Java Integrated Development Environment (**https://www.jetbrains.com/idea/** (https://www.jetbrains.com/idea/))
- Free form environmental models
  - Numerus – **https://www.numerusinc.com/** (https://www.numerusinc.com/)
  - NetLogo – Agent-Based Modeling (**http://ccl.northwestern.edu/netlogo/** (http://ccl.northwestern.edu/netlogo/))
- Statistical languages
  - R - **http://www.r-project.org/** (http://www.r-project.org/) and R Studio - **https://www.rstudio.com/** (https://www.rstudio.com/)

Additional/Outside Readings (helpful but not assigned):

- Bolker, B. Ecological Models and Data in R. Princeton University Press.
- Grimm,V. and Railsback, S. 2005. Agent-based and Individual-based Modeling: A Practical Introduction. Princeton University Press.
- Bloomfield, Victor. Computer simulation and data analysis in molecular biology and biophysics: an introduction using R. Springer, 2009.
- Software Engineering Techniques Applied to Agricultural Systems: An Object-Oriented and UML Approach by Papajorgji, Petraq J. / Pardalos, Panos M. ISBN: 0387281703, Publisher: Springer-Verlag. Published September 2005; Hardcover; 247 pages. (Available in the UF Library as an E-Book)
- Roff, D. 2010. Modeling Evolution: an introduction to numerical methods. Oxford University Press. ISBN 978-0-19-957114-7.
- Forrester, J.W. 1961. Industrial Dynamics. John Wiley. New York.
- Checkland, Peter (1999). Systems Thinking, Systems Practice. London, John Wiley & Sons. ISBN 0-471-98606-2.
- Peart, R.M. and R.B. Curry. 1998. Agricultural Systems Modeling and Simulation. Marcel Dekker, Inc. New York. 696 pp. ISBN: 9780824700416.

Additional reading materials, videos, tutorials, course notes, lectures, web sites and diagrams are also provided online through E-Learning.

Course Outline and Schedule (subject to changes/alterations):

Weeks 1: Class Introduction, Integrated Development Environments and Basic Coding, Complex System Descriptions and Design (Kiker)

Week 2: Complex System Description and Soft Systems Analysis (Kiker)

Week 3: System description with Forrester Diagrams with continued programming (Kiker)

Week 4: Numerical integration with continued programming (Kiker)

Weeks 5 and 6: Expanding the Biological Modeling Toolbox (Kiker)

Weeks 7, 8, 9: Parameter Estimation, Model Testing & Global Sensitivity/Uncertainty Analysis (Kiker & Carpena)

Week 10: Stability analysis: Properties of square matrices (Huffaker)

Week 11: Stability analysis: 1st order differential equations (Huffaker)

Weeks 12 and 13: Stability analysis: Systems of linear differential equations (Huffaker)

Weeks 14 and 15: Stability analysis: Systems of nonlinear differential equations (Huffaker)

Homeworks: This course is primarily graded on a series of assignments to create an overall term project/portfolio. All assignments will be assigned during the laboratory period and due in one week after posting (unless otherwise mentioned in CANVAS). Each student will submit individual written reports, designs and/or presentations that will be graded by the instructor.

- HW 1: Elementary Programming Concepts with IDE's (Assigned Week 1)
- HW 2: Complex Problems with Soft Systems Methodologies (Assigned Week 2)
- HW 3: Forrester Diagrams and Simple Biological Models (Assigned Week 3)
- HW 4: Numerical Integration (Assigned Week 4)
- HW 5: Model Testing and FITEVAL (Assigned Week 6)
- HW 6: Global Sensitivity and Uncertainty Analysis Ready, Set … Bungeeeee! (Assigned Week 7)
- HW 7: Biological Modeling Toolbox - Predator/Prey and Agent-Based Disease models (Assigned Week 8)
- HW 8: Biological Modeling Toolbox - Compartmental and Matrix Models (Assigned Week 9)
- HW 9: Analytical and numerical analysis of stability of species competition model (Assigned Week 11)
- HW 10: Analytical and numerical analysis of stability of nonlinear system model (Assigned Week 13)

Assignments: This course will utilize the E-Learning (Canvas) system for the submission of all homework assignments

On-Line Discussion Lists: Occasionally, we will use the on-line discussion feature of E-Learning (Canvas) system to allow for on-line discussions to share ideas and/or references.

GRADING:

Class Assignments: 100%

- Homework will be assigned and will be due up to 7 - 14 days later.
- Late homework will be accepted at a cost of 10% per day late (Up to a maximum of 50%).

For information on current UF policies for assigning grade points, see **https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx (https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx)**

GRADING SCALE;

A: 93 ≤ HW Average ≤ 100; A-: 90 ≤ HW Average < 93

B+: 87≤ HW Average < 90; B : 83≤ HW Average < 87; B- : 80≤ HW Average < 83;

C+: 77≤ HW Average < 80; C : 73≤ HW Average < 76; C- : 70≤ HW Average < 73;

D+: 67≤ HW Average < 69; D : 63≤ HW Average < 67; D- : 60≤ HW Average < 63;

E : ≤ HW Average =< 60

More information on UF grading policy may be found at: **http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades (http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades)**

Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, https://www.dso.ufl.edu/drc) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at **https://gatorevals.aa.ufl.edu/students/ (https://gatorevals.aa.ufl.edu/students/)** . Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via **https://ufl.bluera.com/ufl/ (https://ufl.bluera.com/ufl/)** . Summaries of course evaluation results are available to students at **https://gatorevals.aa.ufl.edu/public-results/ (https://gatorevals.aa.ufl.edu/public-results/)** .

University Honesty Policy

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (**https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/ (https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/)**) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, **rbielling@eng.ufl.edu (mailto:rbielling@eng.ufl.edu)**
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, **taylor@eng.ufl.edu (mailto:taylor@eng.ufl.edu)**
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, **nishida@eng.ufl.edu (mailto:nishida@eng.ufl.edu)**

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: **https://registrar.ufl.edu/ferpa.html (https://registrar.ufl.edu/ferpa.html)**

Campus Resources:

Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact **umatter@ufl.edu (mailto:umatter@ufl.edu)** so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: http://www.counseling.ufl.edu/cwc (http://www.counseling.ufl.edu/cwc), and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance (https://titleix.ufl.edu/)**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, **title-ix@ufl.edu (mailto:title-ix@ufl.edu)**

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or **http://www.police.ufl.edu/ (http://www.police.ufl.edu/)**.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.

https://lss.at.ufl.edu/help.shtml (https://lss.at.ufl.edu/help.shtml) .

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. **https://www.crc.ufl.edu/** (https://www.crc.ufl.edu/) .

Library Support, **http://cms.uflib.ufl.edu/ask** (http://cms.uflib.ufl.edu/ask) . Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. **https://teachingcenter.ufl.edu/** (https://teachingcenter.ufl.edu/) .

Writing Studio, 302 Tigert Hall*,* 846-1138. Help brainstorming, formatting, and writing papers. **https://writing.ufl.edu/writing-studio/** (https://writing.ufl.edu/writing-studio/) .

Student Complaints Campus*:* **https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf** (https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf) .

On-Line Students Complaints*:* **http://www.distance.ufl.edu/student-complaint-process** (http://www.distance.ufl.edu/student-complaint-process) .

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Course Summary:

Date	Details

Fri Nov 2, 2018	HW 8 Global Sensitivity and Uncertainty Analysis Ready, Set ..... Bungeeeee!!!!!!! (https://ufl.instructure.com/courses/377921/assignments/3915836)	due by 11:59pm
Tue Aug 27, 2019	Homework 1 Elementary Programming Concepts with IDE's (https://ufl.instructure.com/courses/377921/assignments/3915827)	due by 11:59pm
Tue Sep 3, 2019	Homework 2 Soft Systems Methodology (https://ufl.instructure.com/courses/377921/assignments/3915828)	due by 11:59pm
Tue Sep 24, 2019	Homework 3 Diagrams and Simple Biological Models (https://ufl.instructure.com/courses/377921/assignments/3915829)	due by 11:59pm
Tue Oct 8, 2019	Homework 4 - Numerical Integration (https://ufl.instructure.com/courses/377921/assignments/3915830)	due by 11:59pm
Tue Oct 15, 2019	Homework 5 Modeling Tool Box - Predator/Prey and SIR models (https://ufl.instructure.com/courses/377921/assignments/3915831)	due by 11:59pm
	HW 6: Model Testing and FitEval (https://ufl.instructure.com/courses/377921/assignments/3915835)	due by 11:59pm
Fri Dec 6, 2019	Homework 7 Modeling Tool Box - Compartmental and Matrix Models (https://ufl.instructure.com/courses/377921/assignments/3915832)	due by 11:59pm
	Homework 10 Gompertz Growth Model Analytics (https://ufl.instructure.com/courses/377921/assignments/3915826)	
	Huffaker Grade 1 (https://ufl.instructure.com/courses/377921/assignments/3915833)	
	Huffaker Grade 2 (https://ufl.instructure.com/courses/377921/assignments/3915834)	
	HW 9 Scenario Development (https://ufl.instructure.com/courses/377921/assignments/3915837)	
	Model Fit and Testing Part 1 Quiz (https://ufl.instructure.com/courses/377921/assignments/4009912)	
	Model Fit and Testing Part 2 Quiz (https://ufl.instructure.com/courses/377921/assignments/4009915)	
	Model Fit and Testing Part 3 Quiz	

	(https://ufl.instructure.com/courses/377921/assignments/4009918)
	Model Fit and Testing Part 4 Quiz (https://ufl.instructure.com/courses/377921/assignments/4011067)
	Model Fit and Testing Part 5 Quiz (https://ufl.instructure.com/courses/377921/assignments/4011068)
	Model Fit and Testing Part 6 Quiz (https://ufl.instructure.com/courses/377921/assignments/4011127)
	Model Fit and Testing Part 7 Quiz (https://ufl.instructure.com/courses/377921/assignments/4011128)