

# **ABE423 Biosystems Analysis and Design**

**Shantz 440, MWF, 11 am – noon    Spring 2017**

## **Description of Course**

Application of systems analysis to biologically-related problems; computer modeling and use of simulations, optimization methods, decision support systems.

## **Course Prerequisites or Co-requisites**

Adv. Stdg: Engineering and ABE205

## **Instructor and Contact Information**

Peter Waller, Shantz 536, 520-440-5803, pwaller@email.arizona.edu

Monday 1-2/"Open Door Policy"

Teaching assistants: none

Course is conducted in D2L. All videos, pdfs, homeworks, and exams are in D2L.

## **Course Format and Teaching Methods**

There are three lectures per week. All lectures are also online. Many classes focus on skills development with the assumption that students also listen to lectures online.

## **Course Objectives and Expected Learning Outcomes**

### **Course objectives**

The objective of this course is to enable students to analyze biological systems with respect to economics, growth rate, environmental impact, optimization, sustainability, and nutrient scheduling. Students analyze algae/biofuel feedstock production, agriculture, aquaponics, disease models, and predator-prey models. Numerical methods and models in Matlab and Excel/VBA include Euler and Runge-Kutta methods, first-order growth rate equations, epidemiology models, linear programming, and Simulink.

### **Learning objectives**

- Students use Euler and Runge Kutta methods in Matlab, Excel, and Simulink to analyze sets of first order rate equations.
- Students use linear programming methods such as Jacobi and Gauss in Matlab in order to solve sets of linear equations
- Students set up phase diagrams for epidemiology and predator-prey models
- Students set up models for scheduling, optimization, economics, and environmental impact of biological production systems.
- Students analyze agricultural, aquaponic, and algal production systems

## **Absence and Class Participation Policy**

The UA's policy concerning Class Attendance, Participation, and Administrative Drops is available at: <http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop>

The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable, <http://policy.arizona.edu/human-resources/religious-accommodation-policy>.

Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: <https://deanofstudents.arizona.edu/absences>

Class attendance is required. It is 3% of the course grade. It is critical that you coordinate attendance with fellow group members. Failure to submit third-party documentation will result in unexcused absences.

## **Makeup Policy for Students Who Register Late**

Students who sign up late for the class cannot make up assignments.

## **Course Communications**

All course communications will be conducted with UA e-mail address, and D2L

## **Required Texts or Readings**

Online powerpoints, pdfs, computer codes, and videos are available in D2L.

This reference text is free online at U of A. *Numerical Methods in Biomedical Engineering*, SM Dunn, A. Constantinides, and P.V. Moghe, Academic Press, 2006

## **Required or Special Materials**

Students can conduct all assignments on classroom computers. Please bring earphones if you plan to listen to the online lectures in class.

## **Required Extracurricular Activities (if any)**

There are no required extracurricular activities.

## **Assignments and Examinations: Schedule/Due Dates**

Weekly homeworks are turned in as Word documents with Matlab screenshots and/or Excel files.

There are three equally weighted exams (two midterms and the final). If you pass one of the in-class Simulink quizzes near the end of the semester, then you can take the average scores on the best 2 out of 3 exams, and you can select to miss the final if your grade is satisfactory. Otherwise, your exam score is the average of the three exams (two midterms and final).

One group project will be conducted by groups of 4 students. Students will focus on one biological system, but each student will analyze a different part of the system. Students will put the 4 programs together at the end of the semester to develop a complete analysis of the system. Programs can be written in Excel/VBA, Matlab, and/or Simulink.

## **Final Examination or Project**

The final exam takes place at the regularly scheduled time for MWF 11-12 classes.

## Grading Scale and Policies

<u>Criteria</u>	<u>423</u>	<u>523</u>	<u>Grading Scale</u>	
Mid-term Exams	19%	19%	90.0 – 100.0	A
Homework	15%	15%	80.0 – 89.9	B
Topical project	20%	20%	70.0 – 79.9	C
Topical project video or present	5%	5%	60.0 – 69.9	D
Attendance and participation	3%	3%	< 60.0	E
Final exam	19%	19%		

University policy regarding grades and grading systems is available at <http://catalog.arizona.edu/policy/grades-and-grading-system>

**Requests for incomplete (I) or withdrawal (W)** must be made in accordance with University policies, which are available at <http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete> and <http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal> respectively.

**Dispute of Grade Policy** Students are welcome to dispute a grade on a quiz, project, or exam at any time during the semester.

## Honors Credit

Students wishing to contract this course for Honors Credit should email me to set up an appointment to discuss the terms of the contact. Information on Honors Contracts can be found at <http://www.honors.arizona.edu/faculty-and-advisors/contracts>.

## Scheduled Topics/Activities

Jan 11	1-2	Introduction to class and formation of groups
Jan 13	1-3	Introduction to principles of analysis of biological systems: numerical modeling, economics, optimization, sustainability, input management, scheduling, and environmental impact.
Jan 18	2-2	Introduction to RAFT algae/biofuels project, meet at Roger Road
		Economics and sustainability of biofuels projects
Jan 23	3-1	Modeling light, photosynthetic growth, and dark respiration in algae cultures
	3-2	Finite difference method to evaluate algae growth rate – exact solution
	3-3	Finite difference method to evaluate algae growth rate – Euler method
Jan 30	4-1	Error analysis comparison of exact and Euler method (Dunn 3)
	4-2	Error analysis comparison of exact and Euler method (Dunn 3)
	4-3	Fertilizer and carbon dioxide management in algae/biofuel systems
Feb 6	5-1	Economic and environmental analysis and optimization of algae/biofuels
	5-2	Runga-Kutta methods for modeling growth rate in Excel, VBA, and Matlab
	5-3	Runga-Kutta methods for modeling growth rate in Excel, VBA, and Matlab
Feb 13	<b>Exam 1</b>	<b>Exam on Algae/biofuel systems (not including Runga-Kutta)</b>
	6-2	Finite models of higher order differential equations
	6-3	Finite models of higher order differential equations
Feb 20	7-1	Modeling temperature in bioreactors with partial differential equations
	7-2	Modeling temperature in bioreactors with partial differential equations
	7-3	Modeling the height of a flexible membrane over a pond with PDE
Feb 27	8-1	The logistic model of biological growth
	8-2	SIS (Susceptible Infective Susceptible) and SIR models of epidemics
	8-3	Modeling waterborne disease transmission
Mar 6	9-1	Interspecies competition
	9-2	Predator-prey relationships
	9-3	Linear programming in biology (Dunn 4)
Mar 20	10-1	Linear programming in biology (Dunn 4)

	10-2	Introduction to aquaponics systems – tour of systems at CEAC
	10-3	Economics and sustainability of aquaponics systems
Mar 27	<b>Exam 2</b>	<b>Exam 2 Euler/Runga-Kutta to linear programming</b>
	11-2	Aquaponics systems – modeling lettuce growth rate and light requirements
	11-3	Aquaponics systems – modeling fish growth rate and feed requirements
Apr 3	12-1	Modeling nutrients, contaminants and feed in aquaponics systems
	12-2	Economic and environmental analysis and optimization of aquaponics
	12-3	Introduction to farming systems – tour of small farm
Apr 10	13-1	Economics and sustainability of farming systems
	13-2	Scheduling of crops in farming systems
	13-3	Scheduling of nutrient delivery in farming systems
Apr 17	14-1	Scheduling of irrigation in farming systems
	14-2	Economics, optimization, and environmental impact of farming systems
	14-3	Simulink introduction
Apr 24	15-1	Simulink analysis of algae biofuel systems
	15-2	Simulink analysis of aquaponics systems
	15-3	Simulink analysis of predator prey models
May 1	16-1	Student presentations
	16-2	Student presentations
Monday May 8	10:30-12:30	<b>Final exam Aquaponics, farming, and simulink</b>

## Classroom Behavior Policy

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

Students are asked to refrain from disruptive conversations with people sitting around them during lecture. Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.

There are no restrictions on phones or computers in this class. However, during exams, no cell phone use is allowed.

## Threatening Behavior Policy

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See <http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students>.

## Accessibility and Accommodations

Our goal in this classroom is that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, please let me know immediately so that we can discuss options. You are also welcome to contact the Disability Resource Center (520-621-3268) to establish reasonable accommodations. For additional information on the Disability Resource Center and reasonable accommodations, please visit <http://drc.arizona.edu>.

If you have reasonable accommodations, please plan to meet with me by appointment or during office hours to discuss accommodations and how my course requirements and activities may impact your ability to fully participate.

Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

## **Code of Academic Integrity**

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See:

<http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity>.

*Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions.*

Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.

## **UA Nondiscrimination and Anti-harassment Policy**

The University is committed to creating and maintaining an environment free of discrimination; see <http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy>

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others.

## **Additional Resources for Students**

UA Academic policies and procedures are available at <http://catalog.arizona.edu/policies>

Student Assistance and Advocacy information is available at

<http://deanofstudents.arizona.edu/student-assistance/students/student-assistance>

## **Confidentiality of Student Records**

<http://www.registrar.arizona.edu/personal-information/family-educational-rights-and-privacy-act-1974-ferpa?topic=ferpa>

## **Subject to Change Statement**

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.