BE 7350
Advanced Instrumentation and Control for Biological Systems
Spring 2009

A graduate course in biological engineering

Instructor: Steven G. Hall, Ph.D., P.E., Biological and Agricultural Engineering;

Visiting Lecturers TBA

Class Hours: 6-9 PM Monday. Hours may be changed at discretion of instructor.
Location: 115 Doran, by appointment
Dr. Hall's Office: 143 Doran, 578-1049, shall5@lsu.edu

Credit Hours: 3

Course Description: *Prerequisites: BE 2350 or equivalent or consent of instructor; differential equations or equivalent; introductory control concepts suggested.* Advanced instrumentation and control applications in biological systems. Theory of measurement and feedback integrated with applied design work with actual biological systems. Focus areas include aquacultural measurement and control, precision farming, environmental applications of monitoring and control, bioprocess and biomedical control concepts.

Objectives: To explore advanced applications of instrumentation and control related to biological systems, with regard to engineering design. Theory and applications in agricultural, biomedical, environmental, food and other fields will be included.

Texts: Materials Distributed by Dr. Hall (no text required)

References: Coombs, Clyde, Ed., 2000. Electronic Instrument Handbook, 2nd edition, New York: McGraw Hill.

Doeblin, E. O., 1990. Measurement Systems: Application and Design, New York: McGraw Hill.

Liptak, C. 2004. Instrument Engineers Process Control Handbook, CRC Press.

Mohsenin, Nuri N., 1986. Physical properties of plant and animal materials : structure, physical characteristics, and mechanical properties. New York : Gordon and Breach.

Additional References: See separate listing.

Project Guidelines: Each student will be involved in a unique design project related to an area of interest for that student. Typically, relevant projects which combine measurement, control applications and some area of biology or biological systems should be chosen. Use of computers; microcontrollers; PLC's or other relevant technologies will be encouraged.

Student Participation and Discussion Facilitation: Students will share a peer-reviewed article or other relevant topic agreed on by instructor and students (and will share relevant material 1 week in advance), and will facilitate discussion of that topic (typically 5-10 minute opening, 30-60 minute discussion) in class.

Student Presentation: Students will present formally on relevant issues in instrumentation and control of biological systems at least once during the semester --e.g. presenting a review article (15-20 minutes with 5-10 minutes for questions and discussion.

Final Project Presentations: Each student will make a final presentation of their project with review from instructors and other students.

Final Project Reports: Each student will prepare a final project report analogous to a research article, including Introduction, Materials and Methods, Results, Discussion, References, Figures, Tables, as well as any additional areas as appropriate.

Criteria for determining grade:

Discussion facilitation/class participation	20%
Student Presentations (4^{th}-12^{th} week)	20%
Final Project Presentation (week10-15)	20%
Final Project Report (week 14)	40%

Final course grade will be determined from the following scale:
A: 90-100%
B: 80-89%
C: 70-79%
D: 60-69%
F: 0-59%

Late policy: One letter grade reduction each late day after an assignment is due.

Each student will give individual presentations and projects, but collaborative work is expected on class discussions and projects. *Practice* your presentations with other students at least 1 week before formal presentation. *Practice* your timing. *Be prepared* for technical questions. Have other students (or instructors) review your material well before due dates. Encourage each other with constructive criticism.

BE 7350 *Spring 2009* Tentative Course Outline: May Change at Discretion

Date	Topic
1/12a	Introduction, instrumentation review (Omega materials)
1/12b	Control concepts, biological applications introduction
1/19	MLK Day; possible lecture 1/21
1/26a	Datalogger basics: Guest Lecturer: Chiu or Dugas
1/26b	Datalogger applications; Project Discussion
2/2a	Analog Control Theory (P,I,D) Review
2/2b	Digital Control Theory Review; Preliminary Project Proposals Due
2/9a	Minidataloggers: Boxcar/Hobo and other(s)
2/9b	Microcontroller theory and introduction (Hall) Project Proposals Due
2/16	(Hall at WAS) Independent work on Projects
2/23	Mardi Gras; Independent work on Projects
3/2	Control system simulation: MATLAB, SIMULINK
3/2b	Midterm, Project Updates Due
3/9	Discussion: Biological System Properties (Hall leading)
3/9	Guest Lecture: Monroe, Ram and/or Murphy)
3/16	Integration of Instrumentation, Control and Biological Systems
3/16	Discussion: Environmental/Aquacultural Issues (student led);
3/23a	Environmental Applications (Hall, Saidu)
3/23b	Discussion: Biomed or Environmental Issues ()
3/30a	Biomedical Applications (Monroe, Ram and/or Murphy)
3/30b	Discussion: Bioprocess Applications (Boldor)
3/30b	Discussion: Measurement and Control in the Biosphere (Chiu)
3/30	Guest Lecture, Dr. Sabliov or Barbosa
4/6-12	***Spring Break: Final Presentations to Follow as Shown***
4/13	Student Presentations; Ag, Env (Students)
4/13	Student Presentations; Biomed; Env (Students)
4/20	Student Presentations: Biosensors; (Students)
4/20	Student Presentations: Process (Students)
5/27	Student Presentations: Env, Biosensors (Students)
5/27	Conclusion, Party! (under control?) Final Reports due 5/1/09

* Student presentation/facilitation of peer reviewed articles.

** Student presentations of final research reports

Course Outline

BE 7350: Advanced Instrumentation and Control for Biological Systems

Instrumentation theory [Weeks 1-2]

Sensing and measurement;
Transducers;
Analog and digital measurement systems.

Control concepts [Weeks 3-4]

Feedback loops;
Measurement;
Laplace transform methods;
Classical (analog) control theory;
Digital control theory.

Relevant properties of biological systems: [Weeks 5-6]

Spatial and temporal heterogeneity;
Stochasticity; emergent properties;
Growth;
Reproduction and death;
Trophic levels;
Environmental and ecological issues and complexity.

Advanced Instrumentation and Control: Integration: [Weeks 7-8]

Applications of Modeling and Simulation;
Adaptive Control;
Specific Examples of Design and Control Simulation Languages:
- Matlab
- Femlab

Applications in Biological Engineering.

Midterm after week 8

Project Work [Weeks 9-15]

Final Project Suggested Application Areas:

Environmental Applications: [Review Weeks 9]

Environmental monitoring: automated systems for environmental monitoring (e.g. LA State Climatology Project; Theegala-bioreactors);

Agricultural Applications: [Review Week 10]

Aquacultural Applications: Automated monitoring and control in recirculating aquaculture systems (Wheaton; Timmons; Hall; Malone; Rusch).
Precision or Prescription Farming: (Morris) GPS and GIS applications in agriculture and related areas.
Composting Applications: (Hall) Measurement and control of biodegradation systems.

Autonomous Vehicles: [Week 11] (Price, Hall)

Improvements in autonomy of land, air and water based vehicles;
Power systems (e.g. solar photovoltaic, batteries; AC/DC power options);
Control mechanisms (e.g. servos); control processors (e.g. BASIC Stamp)

Biosensors/Biomedical: [Week 12] (Monroe, Murphy)

Applications of instrumentation with and in biosystems.
Protein interactions "proteiomics";
Measurement of physiologically relevant variables;
Biomedical applications (Greatbatch and biomedical history).

Food and Bioprocess Engineering Automation: [Week 13] (Sabliov, Lima, Boldor)

Automated equipment in the food processing industry;
Extrusion processes;
Rice Mill operations.

Final Projects and Presentation Due: [Weeks 14-15]

Reference Reading List
Steven G. Hall, Asst. Professor, 578-1049.

Dally, James W., William F. Riley and Kenneth G. McConnell, 1993. Instrumentation for Engineering Measurements, Second Edition. John Wiley and Sons: New York, 584 pp.

Doeblin, Ernest O., 1990. Measurement Systems, Application and Design, Fourth Edition. McGraw Hill: New York, 960 pp.

Franklin, Gene F., J.David Powell and Michael L. Workman, 1990. Digital Control of Dynamic Systems. Addison-Wesley: Reading Mass, 841 pp.

Karnopp, Dean C., Donald L. Margolis and Ronald C. Rosenberg, 1990. System Dynamics, A Unified Approach, Second Edition. John Wiley and Sons: New York, 514 pp.

Mohsenin, Nuri N., 1986. Physical properties of plant and animal materials : structure, physical characteristics, and mechanical properties. New York : Gordon and Breach, 891 pp.

Norton, Harry N., 1989. Handbook of Transducers. Prentice Hall: Englewood Cliffs, NJ, 554 pp.

Ogata, Katsuhiko, 1990. Modern Control Engineering, Second Edition. Prentice Hall: Englewood Cliffs, NJ, 963 pp.

Omega Catalogs: www.omega.com.

Park, Joon Bu. Biomaterials : an introduction, 1979. New York : Plenum Press. 251 pp.

Parallax website: www.parallaxinc.com

Shahian, B. and Michael Hassul, 1993. Control System Design Using MATLAB. Prentice Hall: Englewood Cliffs NJ, 503 pp.

Stark, G.B. and R. Horch, 1998. Biological matrices and tissue reconstruction. New York : Springer-Verlag.

Students BE 7350, Spring 2009

Name	email	phone
Yin Lin "Jack" Chiu		
Daniel Dehon		
Adam Dows		
Keith Miller		
Daniel Smith		