Engineering Faculty Document No. 26-13

12/17/12

TO: The Faculty of the College of Engineering

FROM: The Faculty of the Weldon School of Biomedical Engineering

RE: New Undergraduate Course, BME 40100, Mathematical and Computational Analysis of Complex System Dynamics in Biology, Medicine, and Healthcare

The Faculty of the Weldon School of Biomedical Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

BME 401000 Mathematical and Computational Analysis of Complex System Dynamics in Biology, Medicine, and Healthcare
Terms offered: Fall or Spring, Lecture 3, Cr. 3
Prerequisites: MA 26200 or MA 26500 and 26600

Description: An introduction to analysis of complex system dynamics that appear in biology, medicine, and healthcare. Key topics include nonlinear dynamical concepts associated with phase plane, bifurcation, stability diagram, oscillation, and chaotic systems along with concepts from discrete systems and stochastic processes. These topics are taught within the context of mathematical and computational models related to both non-communicable diseases (i.e. cancer) and communicable diseases (i.e. HIV/AIDS). Course projects are drawn from recent literature.

Reason: This new course will have direct applications in biomedical applications not found in the other electives. The intent of the course is to provide a rigorous mathematical, quantitative, and analytical foundation for understanding the dynamics in nonlinear, discrete, and stochastic biological, medical, and healthcare systems. More importantly, this course will provide the students an opportunity of applying the knowledge they accumulate through our BME undergraduate curriculum to real-world complex problem solving, in order to further prepare our students with a quantitative perspective to biology, medicine, and healthcare.

This course will be one of a required set of quantitative technical electives (students can choose one) for the undergraduate program in the Weldon School of Biomedical Engineering (BME). These Quantitative Technical Electives teach advanced mathematical concepts within biology, medicine and healthcare. This course has been offered previously as a 400-level experimental course. Historically, this course has been selected by almost all BME seniors. For example, in 2012, there were 50 undergraduates from BME in the course. Primarily, driven by the large undergraduate enrollment, the material covered and the pace of the course is appropriate for a 400-level course.

George R. Wodicka

George R. Wodicka, Professor and Head
Weldon School of Biomedical Engineering

APPROVED FOR THE FACULTY
OF THE SCHOOLS OF ENGINEERING
BY THE ENGINEERING
CURRICULUM COMMITTEE

ECC Minutes 9-20-13

Date

Chairman ECC Jeffrey L. Gray

BME 40100

EFD 26-13

Office of the Registrar
FORM 40 REV. 11/09

PURDUE UNIVERSITY
REQUEST FOR ADDITION, EXPIRATION,
OR REVISION OF AN UNDERGRADUATE COURSE
(10000-40000 LEVEL)

Print Form

DEPARTMENT Biomedical Engineering EFFECTIVE SESSION Fall ~~2013~~ 201420

INSTRUCTIONS: Please check the items below which describe the purpose of this request.

- [X] 1. New course with supporting documents
- [ ] 2. Add existing course offered at another campus
- [ ] 3. Expiration of a course
- [ ] 4. Change in course number
- [ ] 5. Change in course title
- [ ] 6. Change in course credit/type
- [ ] 7. Change in course attributes (department head signature only)
- [ ] 8. Change in instructional hours
- [ ] 9. Change in course description
- [ ] 10. Change in course requisites
- [ ] 11. Change in semesters offered (department head signature only)
- [ ] 12. Transfer from one department to another

PROPOSED:

Subject Abbreviation BME
Course Number 40100
Long Title Mathematical & Computational Analysis of Complex System Dynamics in Biology, Medicine, & Healthcare
Short Title Bio, Med, & Health Analysis

EXISTING:

Subject Abbreviation
Course Number

Abbreviated title will be entered by the Office of the Registrar if omitted. (30 CHARACTERS ONLY)

TERMS OFFERED
Check All That Apply:
[ ] Summer [X] Fall [X] Spring

CAMPUS(ES) INVOLVED
[ ] Calumet [ ] Cont Ed [ ] Ft. Wayne [ ] Indianapolis [ ] N. Central [ ] Tech Statewide [X] W. Lafayette

CREDIT TYPE
1. Fixed Credit: Cr. Hrs. 3
2. Variable Credit Range:
   Minimum Cr. Hrs
   (Check One) To [ ] Or [ ]
   Maximum Cr. Hrs.
3. Equivalent Credit: Yes [ ] No [ ]

COURSE ATTRIBUTES: Check All That Apply
1. Pass/Not Pass Only [ ]
2. Satisfactory/Unsatisfactory Only [ ]
3. Repeatable [ ]
   Maximum Repeatable Credit: [ ]
4. Credit by Examination [ ]
5. Special Fees [ ]
6. Registration Approval Type
   Department [ ] Instructor [ ]
7. Variable Title [ ]
8. Honors [ ]
9. Full Time Privilege [ ]
10. Off Campus Experience [ ]

ScheduleType	Minutes Per Mtg	Meetings Per Week	Weeks Offered	% of Credit Allocated
Lecture	50	3	16	
Recitation				
Presentation				
Laboratory				
Lab Prep				
Studio				
Distance				
Clinic				
Experiential				
Research				
Ind. Study				
Pract/Observ				

Cross-Listed Courses

RECEIVED
OCT 15 2013
OFFICE OF THE REGISTRAR

COURSE DESCRIPTION (INCLUDE REQUISITES/RESTRICTIONS):
Prerequisites: MA 26200 or MA 26500 and 26600. An introduction to analysis of complex system dynamics that appear in biology, medicine, and healthcare. Key topics include nonlinear dynamical concepts associated with phase plane, bifurcation, stability diagram, oscillation, and chaotic systems along with concepts from discrete systems and stochastic processes. These topics are taught within the context of mathematical and computational models related to both non-communicable diseases (i.e. cancer) and communicable diseases (i.e. HIV/AIDS). Course projects are drawn from recent literature.

*COURSE LEARNING OUTCOMES:
Upon completion of the course each student will be able to: 1. Graphically, analytically, and numerically analyze nonlinear dynamical models and numerically analyze discrete-event and stochastic process models of biological, medical, or healthcare systems. 2. Describe possible behaviors of a given system, including how a system may be manipulated within the inherent boundaries. 3. Present, in oral and written format, an analysis and critique of the application of dynamical modeling of a biological system to solve or understand an engineering problem.

Calumet Department Head	Date	Calumet School Dean	Date
Fort Wayne Department Head	Date	Fort Wayne School Dean	Date
Indianapolis Department Head	Date	Indianapolis School Dean	Date
North Central Department Head	Date	North Central Chancellor	Date
George R. Wodicka	4/18/13	[signature]	10/10/13
West Lafayette Department Head	Date	West Lafayette College/School Dean	Date

[signature] 10/17/13
West Lafayette Registrar Date

OFFICE OF THE REGISTRAR

10/17/13

EXAMPLE COURSE SYLLABUS

BME40100 Mathematical and Computational Analysis of Complex System Dynamics in Biology, Medicine, and Healthcare

Fall 2012

Course Instructor: Dr. Nan Kong

Email: nkong@purdue.edu

Office: MJIS 3082

Office Hours: W 10:30 – 11:30 am; F 10:30 – 11:30 am; or by appointment

Course TAs: Jeffrey Perley

Email: jperley@purdue.edu

Office: MJIS1082

Office Hours: M 12:30 – 1:30 pm; T 5 – 7 pm.

Pre-requisites: MA262 or MA265 and MA266

Lecture Time: MJIS 1001, MWF 11:30 am to 12:20 pm

Catalog Description: An introduction to analysis of complex system dynamics that appear in biology, medicine, and healthcare. Key topics include nonlinear dynamical concepts associated with phase plane, bifurcation, stability diagram, oscillation, chaotic systems along with concepts from discrete systems and stochastic processes. These topics are taught within the context of mathematical and computational models related to both non-communicable diseases (i.e. cancer) and communicable diseases (i.e. HIV/AIDS). Course projects are drawn from recent literature..

Course Outcomes: (*Relevant program outcomes are indicated in parentheses*)

Upon completion of the course each student will be able to:

1. Graphically, analytically, and numerically analyze nonlinear dynamical models and numerically analyze discrete-event and stochastic process models of biological, medical, or healthcare systems.

2. Describe possible behaviors of a given system, including how a system may be manipulated within the inherent boundaries.
3. Present, in oral and written format, an analysis and critique of the application of dynamical modeling of a biological system to solve or understand an engineering problem.

Required Textbook: Strogatz, S.H. (1994) "Nonlinear Dynamics and Chaos" West View Press, Cambridge MA. ISBN: 0-7382-0453-6

On Line Resources:

Blackboard will be used to communicate, track grades, post lectures (when available), document assignments, and updates to readings. Please check Blackboard often.

Topics Covered:

- **Classic nonlinear dynamics (textbook)**

1. Nonlinear system properties
2. Phase portraits
3. Stability of fixed points
4. Bifurcation analysis
5. Limit cycles
6. Chaotic systems
7. Discrete systems dynamics
8. Stochastic system dynamics

- **Specific applications in biology, medicine, and public health (lecture notes and additional reading materials)**

1. Introduction to mathematical modeling in epidemiology with emphasis on cancer and HIV
2. Brief introduction to mathematical modeling in computational cancer biology
3. Brief introduction to cost-effectiveness analysis and decision analysis in clinical decision making
4. Brief introduction to mathematical modeling in infectious disease transmission and control

Academic Conduct: You are expected to behave in a professional and ethical manner. Plagiarism or cheating will result in a zero for that particular assignment. If an individual behaves unethically during the semester, the instructor reserves the right to fail the student. For more information, see Purdue University Student Conduct Code at: http://www.purdue.edu/odos/administration/codeconduct.htm.

Grading:

Homework:	5%
Exam I:	15%
Exam II:	15%

Final Exam	20%
Quizzes:	5%
Mini-project I:	10%
Mini-project II:	10%
Final project:	20%
Total	**100%**

Note: Three peer evaluations will take place over the course of the semester. This information may be used in computing the mini and final project grades.

Grade Scale: The following grading scale is just for your reference. Based upon ensemble class performance, final grades will be curved up by the instructor *if appropriate*. The instructor will update on how to curve up the grades after each exam. Students are welcome to discuss his/her progress with the instructor throughout the semester.

>95%	A+
90-95%	A
87-90%	A-
85-87%	B+
80-85%	B
78-80%	B-
75-78%	C+
70-75%	C
65-68%	C-
60-65%	D
<60	F

Homework: Three homework assignment sets will be evenly distributed throughout the semester. All assignments MUST be submitted with hardcopies at the start of the class lecture. *No late assignments will be accepted unless specific arrangements are made.* Students are required to complete the homework independently with help ONLY from the instructor and TA. Students are requested to submit clear and complete solutions. The homework will be evaluated mainly based on the correctness and completeness of the solutions. However, clarity is also an important factor. Students will be asked to take full responsibility for any detected plagiarism.

Exams: Two closed-book exams will be administered during the semester on 9/19 and 11/2 and the final exam will be administered in the finals week. The first exam will mainly evaluate the students' understanding and ability to perform graphical and analytical techniques taught in the course for nonlinear system dynamics. The exam will mainly contain workout problems and short answers. The second exam will mainly evaluate the ability of the students to articulate the significance of nonlinear dynamics analysis. Exams may contain more open-end workout problems and essay questions. The final exam will be a combination of the first two exams. *A practical exam will be distributed before the first exam that contains similar problems and questions as in the real exam.* A preparation guideline will be distributed before the second and final exams. A special review session will be held before each exam. Additional office hours will also be held before each exam date. The first two review sessions are scheduled in MJIS in the evenings before the exam dates. The time and location of the review session for the final exam is TBD. The additional office hours for the first two exams are scheduled at 9 – 10:30 am on 9/19 and 11/1. The time of the additional office hours for the final exam is TBD.

Quizzes: Five 10-minute quizzes will be given at the start of five lectures throughout the semester. The quizzes will be announced during the class prior to the lecture in which the quiz is administered and the topic to be quizzed will be related to what is being taught at the time. They are intended to mainly assess the understanding of the assigned readings. They will also be used to assess the retention, and the understanding and integration of the course material from the previous lecture(s).

Mini-projects: Two mini-projects will be completed during the semester by instructor assigned teams of 2 - 4 students. Teams will be designated by the instructor in a quasi-fair way. Evaluation of every team member's role and contributions will occur upon completion of the mini-projects. Specific instructions will be provided for each mini-project so that it applies or addresses selected topics from the course. It will require you to survey the literature, compare and contrast modeling and analysis approaches, analyze published models, discuss assumptions and limitations of model, develop computer programs, interpret the findings from a biological and healthcare perspective and appropriately document and evaluate the results. The main purpose of the first mini-project is to facilitate you to improve your information literacy in our specific context. The main purpose of the second mini-project is to help you gain computer programming experience in our specific context. The mini-project reports will be evaluated by your instructor and TA for clarity, logical progression, evidence of in-depth understanding, and correctness, in such order.

Final project: A final project will require you to integrate and apply knowledge and skills obtained throughout the course to analyze critical issues related to cancer and HIV/AIDS from a systems dynamical perspective and derive suggestions that may have clinical and public health implications. These projects will be completed in self-selected teams of 4 to 5 students over the last month of the course. A formal presentation of the findings will be presented to the class during the final week(s) of lectures. The final project reports and presentations will be evaluated by your peers, the instructor, and the TA for clarity, logical progression, in-depth understanding, correctness and significance of findings, in such order.

Regrade Policy: Students have the right to contest any grades throughout the semester. In the event that a student feels an assignment has been inappropriately graded, the student must provide a clear explanation for the regrading submission along with the original assignment. Students have **1 week** after the return of a graded assignment to protest a grade; after this time grade disputes will not be accepted. Papers and exams submitted for regrading will be completely reevaluated (i.e., the entire paper will be regraded, not only the portion under protest), which means that students may lose additional points for mistakes missed during the first grading process.

Online Evaluation: During the last two weeks of the semester, you will be provided an opportunity to evaluate this course and your instructor(s). To this end, Purdue has transitioned to online course evaluations. On Monday of the fifteenth week of classes, you will receive an official email from evaluation administrators with a link to the online evaluation site. You will have two weeks to complete this evaluation. Your participation in this evaluation is an integral part of this course. Your feedback is vital to improving education at Purdue University. I strongly urge you to participate in the evaluation system and will provide to-be-determined incentive.

TENTATIVE CLASS OUTLINE AND SCHEDULE

WEEK OF	TOPICS	ASSIGNMENTS AND DUE DATES	ADDITIONAL READING
8/20	Introduction and definition of linear and nonlinear systems. Fixed points, stability, phase portraits for one dimensional system		Ch 1 and 2
8/27	Bifurcations		Ch 3
9/3	More on bifurcations; Review/Textbook examples	HW1 assigned (M)	Ch 3
9/10	Linear 2D system phase portraits; Stability of 2D linear systems	Mini project 1 assigned (M)	Ch 5
9/17	More on Stability of 2D linear systems, Exam 1 review, Phase plane analysis for 2D nonlinear systems; linearization; Review for Exam 1	Exam 1 (Ch1 – Ch5) (1.5 hrs)	Ch 6
9/24	Limit cycle, Poincare-Bendixson Theorem;	HW1 due (M) HW2 assigned (F)	Ch 6 – Ch7
10/1	Bifurcations revisited, Chaos	Mini project 1 due (M);	Ch 7, Ch8, Ch9

		Mini project 2 assigned (F)	
10/8	Discrete Dynamic Systems		Ch10, Handout
10/15	Stochastic Dynamic Systems, pplane 7	HW2 due (F)	
10/22	Cancer cell modeling (tumor growth) Cancer clinical modeling	HW 3 assigned (F); Mini project 2 due (F)	
10/29	Cancer clinical/public health issues Review for Exam 2	Exam 2 (Ch6 – Ch8, cancer)	
11/5	HIV mathematical modeling	Final project assigned (M)	
11/12	AIDS screening/treatment	HW3 due (F)	
11/19	AIDS epidemiology modeling/public health		
11/26	AIDS public/health/Final project team meeting		
12/3	Final project Presentations	Final project powerpoint due Final project report due	

No class dates: 9/3 (Labor Day); 9/19 (Exam I); 10/8 (Fall break); 10/26 (Mini project 2); 11/2 (Exam II); 11/21, 11/23 (Thanksgiving).