TO: The Faculty of the College of Engineering

FROM: The Faculty of Agricultural and Biological Engineering

RE: New Course ABE 44000

The faculty of the Department of Agricultural and Biological Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

ABE 44000 Cell and Molecular Design Principles
Sem. 2, Class 3. Lab 0. Cr. 3.
Requisites, Restrictions, and Attributes: (MA 265 AND MA 266) OR (MA 262 AND MA 303) AND BIOL 230 (or BIOL 231 or BIOL 221)

Description: This course examines the design principles underlying the organization and dynamics of biological networks with an emphasis on genetic/molecular circuits. Topics include the structure and tuning of network motifs and relationship to performance parameters such as robustness to internal noise, temporal response, noise filtering, bi-stability, pattern generation and temporal programs. Examples are presented from the study of natural systems and the design of new synthetic systems.

Reason: Biological circuit design is a foundational component of modern biological engineering with important industry applications in agricultural, environmental, and medical biotechnology. The course provides a foundation for engineering design of cells and genetic circuits. ABE 44000 is one aspect distinguishing the Cellular and Biomolecular specialization from the other BE specializations.

Bernard A. Engel, Professor and Head
Agricultural and Biological Engineering Department

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

ECC Minutes #13
Date 5/10/2013
Chairman ECC

EFD 53-13

Office of the Registrar
FORM 40 REV. 10/10

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

DEPARTMENT: Agricultural and Biological Engineering

EFFECTIVE SESSION: ~~Spring 2013~~ (201410)

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/restrictions
- [ ] 11. Change in semesters offered (department head signature only)
- [ ] 12. Transfer from one department to another

	PROPOSED	EXISTING
Subject Abbreviation	ABE	
Course Number	44000	
Long Title	Cell and Molecular Design Principles	
Short Title	Cell & Molecular Design Prin	

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

TERMS OFFERED (Check All That Apply): [ ] Fall [x] Spring [ ] Summer

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 [ ]

1. Pass/Not Pass Only [ ]
2. Satisfactory/Unsatisfactory Only [ ]
3. Repeatable [ ]
   Maximum Repeatable Credit:
4. Credit by Examination [ ]
5. Special Fees [ ]

COURSE ATTRIBUTES: Check All That Apply

6. Registration Approval Type: Department [ ] Instructor [ ]
7. Variable Title [ ]
8. Honors [ ]
9. Full Time Privilege [ ]
10. Off Campus Experience [ ]

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

RECEIVED
JUN - 6 2013
OFFICE OF THE REGISTRAR

Cross-Listed Courses

RECEIVED
MAY 23 2013
OFFICE OF THE REGISTRAR

COURSE DESCRIPTION (INCLUDE REQUISITES/RESTRICTIONS):

This course examines the design principles underlying the organization and dynamics of biological networks with an emphasis on genetic/molecular circuits. Topics include the structure and tuning of network motifs and relationship to performance parameters such as robustness to internal noise, temporal response, noise filtering, bi-stability, pattern generation and temporal programs. Examples are presented from the study of natural systems and the design of new synthetic systems.

*COURSE LEARNING OUTCOMES

Understand, describe, and calculate quantitative features of biological networks. Create simple, mechanistic models of gene expression. Identify different types of network motifs in biological networks. Describe when particular motifs would be useful for specific types of biological functions. Analyze the dynamics and steady state behavior of simple transcriptional motifs or gene circuits. Tune the parameters of a genetic circuit to design a particular behavior such as a temporal program, an asymmetric filter, or a bistable switch. Design and characterize a transcriptional motif or genetic circuit to result in a particular function, behavior or feature such as robustness, noise filtering, or patterning. Understand the importance of and describe the basic requirements for generating oscillations in cells 1.

	Date		Date
Calumet Department Head		Calumet School Dean	
Fort Wayne Department Head		Fort Wayne School Dean	
Indianapolis Department Head		Indianapolis School Dean	
North Central Faculty Senate Chair		Vice Chancellor for Academic Affairs	
[signature] West Lafayette Department Head	5/17/13	[signature] West Lafayette College/School Dean	5-17-13

[signature] West Lafayette Registrar — Date 6/11/13

OFFICE OF THE REGISTRAR

UD 6/10/13

Office of the Registrar
FORM 40 REV. 10/10

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

EFD 53-13

DEPARTMENT: Agricultural and Biological Engineering   EFFECTIVE SESSION: Spring 2013

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

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	PROPOSED	EXISTING
Subject Abbreviation	ABE	
Course Number	44000	
Long Title	Cell and Molecular Design Principles	
Short Title		

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

TERMS OFFERED (Check All That Apply): [ ] Fall [x] Spring [ ] Summer

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

CREDIT TYPE
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2. Variable Credit Range:
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   (Check One) To [ ] Or [ ]
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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 [ ]

Schedule Type	Minutes Per Mtg	Meetings Per Week	Weeks Offered	% of Credit Allocated
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Presentation				
Laboratory				
Lab Prep				
Studio				
Distance				
Clinic				
Experiential				
Research				
Ind. Study				
Pract/Observ				

Cross-Listed Courses

COURSE DESCRIPTION (INCLUDE REQUISITES/RESTRICTIONS):

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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 Faculty Senate Chair	Date	Vice Chancellor for Academic Affairs	Date
West Lafayette Department Head	Date	West Lafayette College/School Dean (signed)	Date 5/1/12

West Lafayette Registrar   Date

OFFICE OF THE REGISTRAR

ABE 44000 Cell and Molecular Design Principles

COURSE CONTACT INFORMATION:

Name: Jenna Rickus
Phone Number: 765-494-1197
E-mail Address: rickus@purdue.edu
Campus Address: MJIS 2029

Catalog Description: This course examines the design principles underlying the organization and dynamics of biological networks with an emphasis on genetic/molecular circuits. Topics include the structure and tuning of network motifs and relationship to performance parameters such as robustness to internal noise, temporal response, noise filtering, bi-stability, pattern generation and temporal programs. Examples are presented from the study of natural systems and the design of new synthetic systems.

Typically offered Spring. 3 credit hours.

Prerequisites:
(MA 265 AND MA 266) OR (MA 262 AND MA 303) AND BIOL 230 (or BIOL 231 or BIOL 221)

COLLEGE (AGRICULTURE) LEARNING OUTCOMES ADDRESSED BY THIS COURSE

- __x__ Professional Preparation: Demonstrate proficiency in their chosen discipline that incorporates knowledge skills, technology, and professional conduct.
- __x__ Scientific Principles: Demonstrate use of the scientific method to identify problems, formulate and test hypotheses, conduct experiments and analyze data, and derive conclusions.
- __x__ Critical Thinking: Demonstrate critical thinking by using data and reasoning to develop sound responses to complex problems.
- ______ Communication: Demonstrate the ability to write and speak with effectiveness while considering audience and purpose.
- ______ Teamwork: Demonstrate the ability to work effectively as part of a problem-solving team.
- ______ Cultural Understanding: Demonstrate knowledge of a range of cultures and an understanding of human values and points of view of other than their own.
- ______ Social Science Principles: Demonstrate ability to apply social, economic, political, and environmental principles to living in a global community.
- ______ Civic Responsibility: Demonstrate awareness of civic responsibility to community and society at large.
- ______ Lifelong Learning: Demonstrate skills necessary for lifelong learning.

DEPARTMENTAL/PROGRAM LEARNING OUTCOMES ADDRESSED BY THIS COURSE

- __x__ an ability to apply knowledge of mathematics, science, and engineering
- ______ ability to design and conduct experiments, as well as to analyze and interpret data.
- ______ an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

______ an ability to function on multidisciplinary teams
__x___ an ability to identify, formulate, and solve engineering problems
______ an understanding of professional and ethical responsibility
______ an ability to communicate effectively
______ the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
______ a recognition of the need for, and an ability to engage in life-long learning
______ a knowledge of contemporary issues
__x___ an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Course outline of Topics/Syllabus

Week.

1. Transcription networks
2. Simple Gene Regulation, Protein Half Life
3. Transcription Network Motifs
4. Graphical Analysis: State Space, Fixed Points, Vector Fields, Stability
5. 1 node motif: Auto-regulation: Time response, robustness, bi-stability
6. 3 node motif: Feed-forward Loops: Noise Filter/Persistence Detector, Time response, Asymmetric Delay, Pulse Generation
7. 4+ node motifs: Multi-output FFLs, SIMS, DORS, Global Structure/Wiring diagrams
8. Developmental, Signaling, Cellular Networks
9. Midterm Review and Exam
10. Biological Oscillations
11. Robustness of Protein Circuits
12. Patterning in Development
13. Kinetic Proof Reading
14. Optimal Gene Circuit Design
15. Demand Rules for Gene Regulation

Reading List/Textbook

An introduction to systems biology: design principles of biological circuits. Uri Alon. ISBN: 9781584886426.

Example syllabus

ABE 44000 Cell and Molecular Design Principles

Required Textbook

1. An introduction to systems biology: design principles of biological circuits. Uri Alon. ISBN: 9781584886426.

Reference Text

2. Nonlinear Dynamics and Chaos: With Applications To Physics, Biology, Chemistry, and Engineering (Studies in Nonlinearity) [Paperback]. Steven H. Strogatz. ISBN 0-7382-0453-6

Course Learning Objectives:

1. Understand, describe, and calculate quantitative features of biological networks.
2. Create simple, mechanistic models of gene expression.
3. Identify different types of network motifs in biological networks
4. Describe when particular motifs would be useful for specific types of biological functions.
5. Analyze the dynamics and steady state behavior of simple transcriptional motifs or gene circuits.
6. Tune the parameters of a genetic circuit to design a particular behavior such as a temporal program, an asymmetric filter, or a bistable switch.
7. Design and characterize a transcriptional motif or genetic circuit to result in a particular function, behavior or feature such as robustness, noise filtering, or patterning.
8. Understand the importance of and describe the basic requirements for generating oscillations in cells 1

Schedule of Topics is a tentative Plan, but deviations may be made through the semester as we progress.

Grading:

Grading:	25%	Homework/Lab Assignments
	25%	Exam 1
	25%	Exam 2
	25%	Semester Project

Grading Scale:

grade	gpa value	% range
A	4.0	93-100
A-	3.7	90.0-92.9
B+	3.3	87.0-89.9
B	3.0	83.0-86.9
B-	2.7	80.0-82.9
C+	2.3	77.0-79.9
C	2.0	73.0-76.9
C-	1.7	70.0-72.9
D+	1.3	67.0-69.9
D	1.0	63.0-66.9
D-	0.7	60.0-62.9
F	0.0	<60.0

Week	Reading	Monday	Wednesday	Friday (computer lab)
1	Alon: Chapter 1, 2	Introduction, background math, dynamics, design principles	transcription networks	most common biological functions, equations, numerical simulation
2	Alon: Chapter 2,3	motifs, temporal response of gene expression	protein half life	numerical simulation, gene expression
3	Alon: Chapter 3	MLK	motifs versus random networks	protein half life, degradation, dilution
4	Strogatz: Ch. 2, Ch.5	state space, fixed points, vector fields, stability	state space, fixed points, vector fields, stability	vector fields, graphical analysis
5	Alon: Chapter 3,4	autoregulation, robustness	autoregulation, bi-stability	bi-stability
6	Alon: Chapter 4	feedfoward loops	feedfoward loops	FFLs
7	Strogatz Ch.6	biological oscillations	biological oscillations	oscillations
8		review for midterm	midterm	no lab
9	Alon: Chapter 5	Global Structure, Temporal Programs	Global Structure, Temporal Programs	
10	Alon: Chapter 6	developmental networks	signaling, neuronal networks	
11	Alon: Chapter 7	robustness of protein circuits	robustness of protein circuits	
12	Alon: Chapter 8	patterning in development	patterning in development	
13	Alon: Chapter 9	kinetic proof reading	kinetic proof reading	
14	Alon: Chapter 10	optimal gene circuit design	optimal gene circuit design	
15	Alon: Chapter 11	demand rules for gene regulation	demand rules for gene regulation	
16		finals week	finals week	finals week