TO: The Faculty of the College of Engineering

FROM: The Faculty of Agricultural and Biological Engineering

RE: New Course ABE 30800

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 30800 Heat and Mass Transfer in Food and Biological Systems
Sem. 2, Class 3. Lab 0. Cr. 3.
Requisites, Restrictions, and Attributes: ABE 30700

Description: Principles of transport of energy and mass. Mechanisms of heat transfer, heat conduction, heat convection and heat radiation. Development of applications using macroscopic and microscopic balances of energy. Application of thermal energy balances and Fourier's law to describe steady state and transient conduction applications including heat generation. Effect of the geometry on these processes. Basic principles of design of heat transfer equipment and its operation. Application of species mass balances and Fick's law to steady state and transient diffusion problems. Effect of geometry on these processes. Analogies between transport of momentum, heat and mass and applications to the solution of practical problems in the Food Process and Biological Engineering fields.

Reason: This course replaces CHE 37800 in the Biological Engineering Plan of Study. Development of a new laboratory course that complements this and two other courses along with increases in the number of students in the Biological Engineering program made it desirable for the Department faculty to teach the subject. This course develops a fundamental understanding of heat and mass transfer through theoretical analysis and applications to physical phenomena of relevance to food process and biological engineering. Also it integrates concepts of momentum, heat, and mass transport to acquire an understanding of the interrelationship of these multi-physics phenomena. Application of concepts to solution of problems of practical importance in biological engineering and allied fields and continued development of problem-solving skills are also emphasized.

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 51-13

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	Subject Abbreviation	
Course Number	30800	Course Number	
Long Title	Heat and Mass Transfer in Food and Biological Systems		
Short Title	Heat & Mass Trans Food & Bio Sys		

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 [ ]

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
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 2 3 2013~~
OFFICE OF THE REGISTRAR

COURSE DESCRIPTION (INCLUDE REQUISITES/RESTRICTIONS):

Principles of transport of energy and mass. Mechanisms of heat transfer, heat conduction, heat convection and heat radiation. Development of applications using macroscopic and microscopic balances of energy. Application of thermal energy balances and Fourier's law to describe steady state and transient conduction applications including heat generation. Effect of the geometry on these processes. Basic principles of design of heat transfer equipment and its operation. Application of species mass balances and Fick's law to steady state and transient diffusion problems. Effect of geometry on these processes. Analogies between transport of momentum, heat and mass and applications to the solution of practical problems in the Food Process and Biological Engineering fields. Requisites, Restrictions, and Attributes: ABE 30700

*COURSE LEARNING OUTCOMES

Understand and apply basic microscopic and macroscopic mass, thermal energy, and species mass balances to solve problems in Food Process and Biological Engineering. Understand mechanisms of heat transfer – conduction, convection, and radiation. Apply thermal energy balances and Fourier's Law to steady-state and transient conduction problems. Apply thermal energy balances and Newton's Law of Cooling to convective heat transfer. Apply correlations to estimate convection coefficients in systems of interest to Biological Engineering. Apply basic design to heat transfer equipment and analyze its operation. Apply the species mass balances and Fick's Law to solve steady-state and transient diffusion problems in Biological Engineering. Apply species mass balance and relevant rate equations to convective mass transfer in Biological Engineering. Understand analogies between transport of momentum, heat, and mass and applications of practical problems Food Process and Biological Engineering. Apply transport

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 5/17/13	Date	West Lafayette College/School Dean 5-17-13	Date
West Lafayette Registrar 6/10/13	Date		

OFFICE OF THE REGISTRAR

6/7/13

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 51-13

DEPARTMENT: Agricultural and Biological Engineering EFFECTIVE SESSION: Spring 2013

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Subject Abbreviation	ABE	Subject Abbreviation	
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Short Title			

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Check All That Apply:
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(Check One) To [ ] Or [ ]
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COURSE ATTRIBUTES: Check All That Apply
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5. Special Fees [ ]
6 Registration Approval Type
Department [ ] Instructor [ ]
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Lab Prep				
Studio				
Distance				
Clinic				
Experiential				
Research				
Ind. Study				
Pract/Observ				

Cross-Listed Courses

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North Central Faculty Senate Chair	Date	Vice Chancellor for Academic Affairs	Date
West Lafayette Department Head	Date	West Lafayette College/School Dean	Date
		West Lafayette Registrar	Date

OFFICE OF THE REGISTRAR

ABE 30800 Heat and Mass Transfer in Food and Biological Systems

COURSE CONTACT INFORMATION:

Name: Osvaldo H Campanella
Phone Number: 765-496-6330
E-mail Address: campa@purdue.edu
Campus Address: NLSN 2151

Catalog Description. Principles of transport of energy and mass. Mechanisms of heat transfer, heat conduction, heat convection and heat radiation. Development of applications using macroscopic and microscopic balances of energy. Application of thermal energy balances and Fourier's law to describe steady state and transient conduction applications including heat generation. Effect of the geometry on these processes. Basic principles of design of heat transfer equipment and its operation. Application of species mass balances and Fick's law to steady state and transient diffusion problems. Effect of geometry on these processes. Analogies between transport of momentum, heat and mass and applications to the solution of practical problems in the Food Process and Biological Engineering fields.

Requisites, Restrictions, and Attributes: ABE 30700

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.
- X 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
X	ability to design and conduct experiments, as well as to analyze and interpret data.
X	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
X	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
X	the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
X	a recognition of the need for, and an ability to engage in life-long learning
X	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

Heat and Mass Transfer Basic concepts

Conduction

Dimensional, Steady-State Conduction

Transient Conduction

Description of available software for Heat and Mass Transfer computer simulation (e.g. Comsol)

Heat Convection

External Flows Internal Flows

Free Convection

Diffusion in Dilute Solutions Dimensional, Steady-State Diffusion

Transient Diffusion Heat Convection

External Flows and Internal flow

Combined Heat and Mass Transfer Problems Radiation Heat Transfer (2 weeks)

Reading List/Textbook

Textbook

Biological and Bioenvironmental Heat and Mass Transfer, Ashim K. Datta, Marcel Dekker 2002, ISBN 0-8247-0775-3. http://catalog.lib.purdue.edu/Find/Record/3138700

Reference Books

- *Transport Phenomena*, R.B. Bird, W.E. Stewart, E.N. Lightfoot, John Wiley and Sons, Inc., 1960, ISBN 0-47-07392-x.

- *Fundamentals of Heat and Mass Transfer*, F.P. Incropera and D.P. Dewitt, 6th Edition, J. Wiley and Sons, Inc., 1996, ISBN 0-471-30460-3.
- *Diffusion: Mass Transfer in Fluid Systems*, E.L. Cussler, 2nd Edition, Cambridge University Press, Inc., 1997, ISBN 0-521-56477-8.
- *Fundamental Principles of Heat Transfer.* Whitaker, S. 1983. Robert Krieger Publishing Company, Florida.

Advanced Books

- *The Mathematics of Diffusion*, J. Crank, 2nd Edition, Clarendon Press, Inc., 1975, ISBN 0-19-853411-6. (on reserve at the Engineering Library-Potter)
- *Conduction of Heat in Solids*, H.S. Carslaw, J.C. Jaeger, Clarendon Press, Inc., 1959, ISBN 0-19-853368-3. (on reserve at the Engineering Library-Potter)

Example syllabus

ABE 30800 Heat and Mass Transfer in Food and Biological Systems

Course Learning Objectives:

1. understand and apply basic microscopic and macroscopic mass, thermal energy, and species mass balances to solve problems in Food Process and Biological Engineering,

2. understand mechanisms of heat transfer – conduction, convection, and radiation.

3. apply thermal energy balances and Fourier's Law to steady-state and transient conduction problems.

4. apply thermal energy balances and Newton's Law of Cooling to convective heat transfer.

5. apply correlations to estimate convection coefficients in systems of interest to Biological Engineering

6. apply basic design to heat transfer equipment and analyze its operation.

7. apply the species mass balances and Fick's Law to solve steady-state and transient diffusion problems in Biological Engineering.

8. apply species mass balance and relevant rate equations to convective mass transfer in Biological Engineering.

9. understand analogies between transport of momentum, heat, and mass and applications of practical problems Food Process and Biological Engineering,

10. apply transport phenomena to the design of bioprocessing equipment and analysis of their operation.

Class	Date	Subject	Assignment
1	Mon 1/7	Syllabus – Introduction – Review of Thermo	
2	Wed 1/9	Introduction to Heat and Mass Transfer	
3	Fri 1/11	- Heat & Mass Transport Analogy	**HW1 – posted**
4	Mon 1/14	*Conduction:* Fourier's Law; Thermal Properties of Matter	
5	Wed 1/16	*Conduction:* Fourier's Law; Thermal Properties of Matter; Boundary & Initial Conditions.	
6	Fri 1/18	*Conduction*: Examples	**HW 2 posted**
	Mon 1/21	**MLK Day – No class**	
7	Wed 1/23	*1-Dimensional, Steady-State Conduction*: Plane wall; Radial systems	
8	Fri 1/25	*1-Dimensional, Steady-State Conduction:* Conduction w/ Thermal Energy	**HW 3 posted**
9	Mon 1/28	*1-Dimensional, Steady-State Conduction:* Conduction from Extended Surfaces.	
10	Wed 1/30	*Transient Conduction*: Lumped Capacitance	
11	Fri 2/1	*Transient Conduction*:: Plane Wall, Radial, and Spherical Convection	**HW 4 posted**
12	Mon 2/4	Semi-Infinite Solid	
13	Wed 2/6	Semi-Infinite Solid	
14	Fri 2/8	**Introduction to Comsol**	**HW 5 posted**
15	Mon 2/11	**Make-Up and Review**	
16	Wed 2/13	**Exam I (Classes 1-14)**	
17	Fri 2/15	*Diffusion in Dilute Solutions:* Fick's Law; Concentrations & Velocities	
18	Mon 2/18	*Diffusion in Dilute Solutions:* Fick's Law; Concentrations & Velocities; Conservation Equations	
19	Wed 2/20	*Introduction to Diffusion Coefficients Parameters*	
20	Fri 2/22	*1-Dimensional, Steady-State Diffusion*	**HW 6 posted**
21	Mon 2/25	*1-Dimensional, Steady-State Diffusion*)	
22	Wed 2/27	*Transient Diffusion*	
23	Fri 3/1	*Transient Diffusion* (cont.)	**HW 7 posted**

Class	Date	Subject	Assignment
24	Mon 3/4	*Introduction to Convection*	
25	Wed 3/6	*Boundary Layer Similarity, Dimensionless Parameters*	
26	Fri 3/8	*Transport analogies and Turbulence*	
	3/11-16	*Spring Breeks*	
27	Mon 3/18	*External Flow*: Empirical Method & Flat Plate	
28	Wed 3/20	**Make-Up and Review**	
29	Fri 3/22	**Exam II (Classes 18-31)**	**HW 8 posted**
30	Mon 3/25	*External Flow* (cont.)	
31	Wed 3/27	*External Flow* (cont.)	
32	Fri 3/29	*External Flow* (cont.)	**HW 9 posted**
33	Mon 4/1	*Energy Balance, Laminar Flow in Circular Tubes, Convection Correlations*	
34	Wed 4/3	*Internal Flow*: Hydrodynamic and Thermal Considerations	
35	Fri 4/5	*Internal Flow* (cont.)	**Hw 10 posted**
36	Mon 4/8	*Introduction to Free Convection*	
37	Wed 4/10	*Free Convection* (cont.)	
38	Fri 4/12	*Free Convection* (cont.)	**HW 11 posted**
39	Mon 4/15	*Introduction to Boiling and Condensation*	
40	Wed 4/17	*Boiling and Condensation*	
41	Fri 4/19	*Radiation Heat Transfer*	**HW 12 posted**
42	Mon 4/22	*Radiation Heat Transfer*	
43	Wed 4/24	*Radiation Heat Transfer*	
44	Fri 4/26	**Make-Up and Review**	
	Mon 4/29	**Final week (Final)**	