PURDUE
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2013-2014

Agricultural and Biological Engineering Student Handbook

Biological Engineering

(For students beginning college career Fall 2013)

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Agricultural & Biological Engineering
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This handbook is a guide. Changes may have been made since this version was completed. Please see your advisor if you have questions. If you need to see an older version of the handbook, please contact Yvonne (room 201 or hardebey@purdue.edu).

Introduction

Welcome to Purdue University and the Department of Agricultural and Biological Engineering!

The Agricultural and Biological Engineering Department is dedicated to providing a stimulating, educational environment for *all* students. The faculty and staff in the Department are committed to assisting students toward enriching, rewarding, and professional experiences at Purdue.

This handbook has been prepared to help students understand the requirements for their major, give guidance for selecting various elective courses in order to achieve success in their academic careers at Purdue University, and also provide useful information about the academic aspects of the department.

The Department of Agricultural and Biological Engineering (ABE) at Purdue University applies engineering and management principles to agriculture, food, and biological systems. A college education in one of the programs of the Agricultural and Biological Engineering Department will prepare students for many exciting career opportunities in the diverse areas of production of food and other biological materials, processing systems, and management of land and water resources. A student can select from these programs: Agricultural Engineering [specializing in either Machine Systems Engineering (MSE) or Environmental and Natural Resources Engineering (ENRE)], or Biological Engineering. The Biological Engineering program will be explained in this handbook.

Biological Engineering graduates are employed in food and/or biologically related industries where their activities include: research and development of new foods or biological and pharmaceutical products; development and operation of manufacturing, packaging and distribution systems for pharmaceutical, food, and bio-based products; design and installation of production processes and/or plant engineering; distribution and marketing; quality evaluation and control; sanitation and waste disposal; and by-product utilization. There is also a great need for biological and food process engineers as educators, production and processing managers, and food industry executives.

The plan of study leads to a degree of Bachelor of Science in Biological Engineering (B.S.B.E.). They are administered by the College of Engineering and the College of Agriculture. Beginning students can apply for admission to the College of Engineering and complete the First-Year Engineering Program. An alternative for students with an interest in biological engineering is to apply to the Pre-Agricultural and Biological Engineering program in the College of Agriculture. Dual-degree programs also are available in Biological Engineering/Biochemistry or Biological Engineering/Pharmaceutical Sciences. These programs require an additional year of study and lead to two degrees. The department also offers graduate study leading to the degrees of Master of Science (M.S.) or Doctor of Philosophy (Ph.D.). We also offer a 5 year dual BS/MS degree in each of our areas in which you can apply at the end of your sophomore year.

According to the strategic plan of the department, published in January 1997, the mission of the department is:

> *"To prepare students, citizens, and industry for the future through innovative education and extension/outreach programs and the discovery of knowledge."*

Educational Objectives and Program Outcomes

With input from various constituency groups and students, the Department of Agricultural and Biological Engineering has established education goals and objectives for its various programs.

Educational Goal

Provide students with learning opportunities that prepare them for future challenges in food, agricultural and biological engineering through the application and discovery of knowledge.

Educational Objective

The educational objectives of the Agricultural and Biological Engineering Department's programs are to produce graduates who:

- Effectively practice Biological Engineering in the areas of design and operation of systems for processing of biological materials to develop products for the food, pharmaceutical, and biochemical industries.
- Have demonstrated proficiency in fundamental engineering skills and technical knowledge as well as in professional and personal skills appropriate for their profession.
- Are prepared for future challenges in Biological Engineering through the application and discovery of knowledge.
- Learn and grow as individuals, contribute to society, and attain maximum potential through lifelong learning.

To achieve the program educational objectives, the department will:

- Recruit, support, and retain competent faculty and staff.
- Provide facilities and equipment to create an atmosphere conducive to learning and discovery and to the application of knowledge.

Program Outcomes

Program outcomes refer to the important capabilities and skills that a student should possess as a graduate of one of the engineering undergraduate programs in the department. Outcomes for Biological Engineering (BE) are divided into two groups: "basic engineering skills" and "professional and personal skills".

Student Outcomes:

To prepare graduates to attain program education objectives.

Graduates of this program will demonstrate:

a. An ability to apply knowledge of mathematics, science, and engineering
b. An ability to design and conduct experiments, as well as to analyze and interpret data
c. 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.
d. An ability to function on multi-disciplinary teams.
e. An ability to identify, formulate, and solve engineering problems
f. An understanding of professional and ethical responsibility.
g. An ability to communicate effectively.
h. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
i. A recognition of the need for, and an ability to engage in life-long learning.
j. A knowledge of contemporary issues.
k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Student Academic Center

In response to the department's strategic goal to: *"Provide students with effective educational opportunities to learn and grow as individuals, contribute to society, and attain maximum potential through life-long learning,"* the Student Academic Center was established. The Center is located in room 201 of the ABE building. Some of the services provided by the Center are:

- assist students with course selection and registration
- assist students with schedule adjustments to develop an appropriate academic schedule each semester
- maintain an up-to-date copy of each student's academic record
- collect and disseminate information relative to all undergraduate activities such as registration procedures, changes in regulations, and new course offerings
- serve as a distribution center for information related to internships, employment, and scholarships
- arrange for interviews with potential employers
- direct students to the correct resource on specific problems that cannot be resolved at the Center.

Advising

In addition to the advising services offered by the Center, each student in the Department is assigned to a faculty advisor who has expertise in the student's area of interest. Normally the same academic advisor is retained until graduation. The advisor will counsel on the academic requirements of the major and serve as a resource to answer other academic concerns, and will assist the students to develop their career goals and objectives. It is also hoped that the advisor will become a friend, listener, and source of information concerning non-academic matters if the need arises.

Student Responsibilities

Any specific interests or concerns you have in the Agricultural and Biological Engineering Department should be discussed with your advisor and/or the Student Services Coordinator. ***Students have the responsibility of initiating and maintaining contact with their advisor for guidance.*** It is important to remember that it is the student who is ultimately responsible for making sure course requirements are complete. The student record sheet in this handbook should be kept up-to-date and checked periodically against the ones in the advisor's file and the permanent file in the Center.

Employment Support

Qualified students often find jobs prior to graduation. Notices of available positions received in the department are posted on the job placement bulletin board located in the hallway of the second floor between rooms 213 and 214 and email from our Placement Coordinator (if you are not receiving emails with placement information, contact the placement coordinator in ABE 201). These notices include full- and part-time positions, summer and internship opportunities. Interview schedules are arranged by the Placement Coordinator. Many students find full-time employment with organizations that have employed them during previous summers/internships.

University Regulations

Purdue has policies regarding discrimination, scholastic deficiency (probation or being dropped), harassment, honor code, fees, grade appeals, hazing, insurance, computer copyrights, and many other student concerns. Please take time to look over the University Regulations Handbook.

Programs in the Department of Agricultural and Biological Engineering

Agricultural Systems Management (ASM)

Agricultural Systems Management prepares individuals to organize and manage technology-based businesses, with emphasis on planning and directing an industry or business project with responsibility for results. ASM students develop skills in communications, business management, computers, and the agriculture sciences, in addition to technical courses based in the Agricultural and Biological Engineering Department. National and international job opportunities include: manufacturing and processing operations; technical services and diagnostics; building and equipment systems; materials handling and process flow; technical product application and sales; product evaluation and education; and production agriculture.

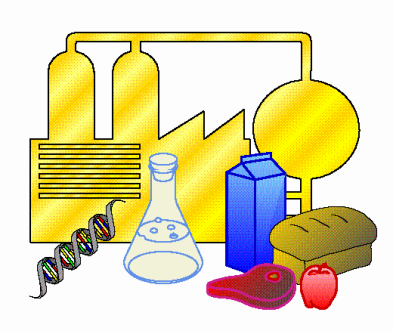
Agricultural Engineering (AE)

Agricultural engineers apply their knowledge of agricultural systems, natural resources, and engineering to equipment design and assure environmental compatibility of practices used by production agriculture. The Agricultural Engineering curriculum offers great breadth, with specialization choices in machine systems engineering and environmental and natural resources engineering. Subject areas include computer-aided engineering, fluid power, finite element analysis, natural resource conservation, and engineering properties of biological materials. Excellent career opportunities exist in product engineering, equipment research and design, facilities design, environmental consulting, and engineering management.

Biological Engineering (BE)

The need for high quality, naturally derived biological products, such as foods, pharmaceuticals, and biochemicals has produced a high demand for knowledgeable, capable engineers who understand the complexity and sophistication of biological materials, combined with solid engineering skills. Employment and career advancement opportunities have been excellent for graduates, not only nationally, but also internationally. Graduates are successful in various positions in the biological and food process industry such as research development, process and product development, environmental and corporate engineering, and management.

Biological Engineering



The need for high quality, naturally derived biological products, foods, pharmaceuticals, and biochemicals has produced a high demand knowledgeable, capable engineers who understand the complexity and sophistication of biological materials, combined with solid engineering

Biological Engineers apply basic scientific and engineering principles to products and processes involving biological and food systems, such as:

- research and development of new foods, biological and pharmaceutical products
- development and operation of manufacturing, packaging and distributing systems for drug/ food products
- design and installation of food/biological/pharmaceutical production processes
- design and operation of environmentally responsible waste treatment systems
- marketing and technical support for manufacturing plants.

The Biological Engineering program leads to an ABET-accredited B.S. degree from the College of Engineering. The Biological Engineering curriculum includes basic science courses (Biology, Chemistry, Physics) as well as organic, physical, and food chemistry. Courses in engineering involve thermodynamics, kinetics, unit operations, and engineering design and cover both theoretical and practical aspects of engineering analysis and design. In the senior year, you will have the opportunity to apply your knowledge to the solution of actual food, biological and pharmaceutical processing problems. You will learn about designing unit operations, such as extrusion, emulsification, heat exchangers, sheeting, sterilization, aseptic processing, freezing, membrane separations, protein purification, evaporation, extraction, fermentation, and packaging, and integrate these with process design principles to design fermentation, enzymatic, and food products/ processes. Employment and career advancement opportunities have been excellent for graduates, not only nationally, but also internationally.

Dual degree programs involving Biochemistry or Pharmaceutical Sciences result in two degrees, one in engineering and one in either biochemistry or pharmaceutical sciences. This would require an additional year of courses. These degrees are focused, intense programs of study targeted to provide graduates with unique skills and job opportunities to take on roles of technical leadership in biological engineering in the next century.

For example, genetic engineering of foods and pharmaceuticals is a target growth technology for the next century involving the manipulation of the genes of microbial, plant, insect and animal cells to alter their processing and product capacities. The dual degree programs are highly inter-disciplinary and prepare graduates with an excellent combination of scientific and engineering skills to work in industries involving state-of-the-art technologies such as genetic engineering.

While classes and grades are very important, there are many other important skills to learn at a university. These programs also include education in interpersonal management and communications skills, such as interviewing techniques, leadership training, management supervision opportunities, professional development and much more. An internship or coop experience is not required, but is highly recommended. Overall, a well-rounded education is the best way to plan for your future.

5 year Dual-Degrees options

Biological Engineering / Biochemistry
Biological Engineering / Pharmaceutical Sciences

Biological Engineering

Cellular and Biomolecular Engineering Plan of Study

Biological Engineering: Cellular and Biomolecular Engineering

https://ag.purdue.edu/oap/Pages/major.aspx

Credits	Course number	Course Title	Prerequisites	Credits	Course number	Course Title	Prerequisites
	Fall 1st Year				**Spring 1st Year**		
4	CHM 11500	General Chemistry	pre/co: calculus	4	CHM 11600	General Chemistry	CHM 11500
4	ENGL 10600	First-Year Composition		3	COM 11400	Fundamentals of Speech Communication	
2	ENGR 13100	Tranforming Ideas to Innovation I		2	ENGR 13200	Transforming Ideas to Innovation II	ENGR 13100
4	MA 16500	Plane Analytic Geometry and Calculus I	ALEKS 75+	4	MA 16600	Plane Analytic Geometry and Calculus II	MA 16500
3	_ _ _ _ _ _ _	UCC ApprovedHumanities Selective		4	PHYS 17200	Modern Mechanics	MA 16500
17				**17**			
	Fall 2nd Year				**Spring 2nd Year**		
4	ABE 20100	Thermodynamics of Biological Systems I	CHM 11500, PHYS 17200	3	ABE 20200	Thermodynamics of Biological Systems II	ABE 20100
1	ABE 29000	Sophomore Seminar		3	CHE 32000	Statistical Modeling and Quality Enhancement	MA 26200
3	BIOL 23000 or BIOL 23100	Biology of the Living Cell or Cell Structure and Function	CHM 11600	3	CNIT 22700 or IT 22700	Bioinformatics or Biotechnology Laboratory II	
4	CHM 25700 or (CHM 25500 and CHM 25501)	Organic chemistry or (Organic chemisry I and Organic chemistry Lab I)	CHM 11500, PHYS 17200	3	MA 26500	Linear Algebra	MA 26100
2	IT 22600	Biotechnology Laboratory I		3	MA 26600	Differential Equations	MA 26100
4	MA 26100	Multivariate Calculus	MA 16500.	3	_ _ _ _ _ _ _	Economics Selective	
18				**17**			
	Fall 3rd Year				**Spring 3rd Year**		
3	ABE 30100	Modeling and Computation Tools in Biological Engineering	ABE 20200 and MA 26600	3	ABE 30400	Bioprocess Engineering laboratory	ABE 30300
3	ABE 30300	Applications of Physics and Chemistry to Biological Processes	ABE 20200	3	ABE 30800	Heat and Mass Transfer in Food and Biological Systems	ABE 30700
3	ABE 30700	Momentum Transfer in Food and Biological Systems	ABE 20200, MA 26500, 26600	3	ABE 37000	Biological/Mircobial Kinetics and Reaction Engineering	BIOL 22100
3	_ _ _ _ _ _ _	Biological Science Selective		3	ABE 45700	Transport Operations in Food and Biological Engineering I	pre/co: ABE 30800
2	_ _ _ _ _ _ _	Humanities or Social Science Selective		3	_ _ _ _ _ _ _	Humanities or Social Science Selective	
14				**15**			
	Fall 4th Year				**Spring 4th Year**		
3	ABE 46000	Sensors and Process Controls	MA 26600	3	ABE 44000	Cell and Molecular Design Principles	MA 26500, 26600, BIOL 23000
1	ABE 49000	Professional Practice in Agricultural and Biological Engineering	ABE 29000	3	ABE 55800	Process Design for Food and Biological Systems	ABE 55700
3	ABE 55700	Transport Operations in Food and Biological Engineering II	ABE 45700	3	ABE 58000	Process Engineering Of Renewable Resources	ABE 37000
3	_ _ _ _ _ _ _	Biological Science or Science Selective		3	_ _ _ _ _ _ _	Engineering Selective	
3	_ _ _ _ _ _ _	Written or Oral Communication Selective		3	_ _ _ _ _ _ _	Humanities or Social Science Selective (30000+ level)	
2	_ _ _ _ _ _ _	Elective					
15				**15**			

128 semester credits required for Bachelor of Science degree.
2.0 GPa required for Bachelor of Science degree.

Biological Engineering: Cellular and Biomolecular Engineering

https://ag.purdue.edu/oap/Pages/major.aspx 128 credits required for graduation

	Credits	Course number	Course Title
Departmental/Program Major Courses (126 credits)			
	Required Major Courses (45 credits)		
_____	4	ABE 20100	Thermodynamics of Biological Systems I
_____	3	ABE 20200	Thermodynamics of Biological Systems II
_____	1	ABE 29000	Sophomore Seminar
_____	3	ABE 30100	Modeling and Computation tools in Biological Engineering
_____	3	ABE 30300	Applications of Physics and Chemistry to Biological Processes
_____	3	ABE 30400	Bioprocess Engineering laboratory
_____	3	ABE 30700	Momentum Transfer in Food and Biological Systems
_____	3	ABE 30800	Heat and Mass Transfer in Food and Biological Systems
_____	3	ABE 37000	Biological/Mircobial Kinetics and Reaction Engineering
_____	3	ABE 44000	Cell and Molecular Design Principles
_____	3	ABE 45700	Transport Operations in Food and Biological Engineering I
_____	3	ABE 46000	Sensors and Process Controls
_____	1	ABE 49000	Professional Practice in Agricultural and Biological Engineering
_____	3	ABE 55700	Transport Operations in Food and Biological Engineering II
_____	3	ABE 55800	Process Design for Food and Biological Systems
_____	3	ABE 58000	Process Engineering Of Renewable Resources
	Other Departmental /Program Course Requirements (81 credits) (See Advising Resources)		
_____	2	ENGR 13100	Tranforming Ideas to Innovation I
_____	3	BIOL 23000 or 23100	Biology of the Living Cell or Cell Structure and Function
_____	3	CNIT 22700 or IT 22700	Bioinformatics or Biotechnology Laboratory II
_____	4	CHM 11500	General Chemistry (satisfies Science #1 for core)
_____	4	CHM 11600	General Chemistry (satisfies Science #2 for core)
_____	4	MA 16500	Plane Analytic Geometry and Calculus I (satisfies Quantitative Reasoning for core)
_____	3	CHE 32000	Statistical Modeling and Quality Enhancement
_____	4	MA 16600	Plane Analytic Geometry and Calculus II
_____	4	MA 26100	Multivariate Calculus
_____	4	PHYS 17200	Modern Mechanics
_____	4	ENGL 10600	First-Year Composition (satisfies Written Communication for core) (satisfies Information Literacy Selective for core)
_____	3	COM 11400	Fundamentals of Speech Communication (satisfies Oral Communication for core)
_____	3	_ _ _ _ _ _ _	Written or Oral Communications Selective
_____	3	_ _ _ _ _ _ _	Economics Selective (satisfies Human Culture Behavioral/Social Science for core)
_____	3	_ _ _ _ _ _ _	UCC Humanities Selective (satisfies Human Cultures Humanities for core)
_____	2	_ _ _ _ _ _ _	Humanities or Social Science Selective
_____	3	_ _ _ _ _ _ _	Humanities or Social Science Selective
_____	3	_ _ _ _ _ _ _	Humanities or Social Science Selective (30000+ level)
_____	2	ENGR 13200	Tranforming Ideas to Innovation II
_____	2	IT 22600	Biotechnology Laboratory I
_____	4	CHM 25700 or (CHM 25500 and CHM 25501)	Organic chemistry or (Organic chemisry I and Organic chemistry Lab I)
_____	3	MA 26500	Linear Algebra
_____	3	MA 26600	Differential Equations
_____	3	_ _ _ _ _ _ _	Biology Selective
_____	3	_ _ _ _ _ _ _	Biology or Science Selective
_____	3	_ _ _ _ _ _ _	Engineering Selective
Electives (2 credits)			
_____	2	_ _ _ _ _ _ _	Elective

University Core Requirements:

Human Cultures Humanities: _____ *Science, Technology, and Society:* _____
Human Cultures Behavioral/Social Science: _____ *Written Communication:* _____
Information Literacy: _____ *Oral Communication:* _____
Science #1: _____ *Quantitative Reasoning:* _____
Science #2: _____

128 semester credits required for Bachelor of Science degree.
2.0 GPa required for Bachelor of Science degree.

Food and Bioprocessing Engineering Plan of Study

Biological Engineering: Food and Biological Process Engineering

https://ag.purdue.edu/oap/Pages/major.aspx

Credits	Course number	Course Title	Prerequisites	Credits	Course number	Course Title	Prerequisites
	Fall 1st Year				**Spring 1st Year**		
4	CHM 11500	General Chemistry	pre/co: calculus	4	CHM 11600	General Chemistry	CHM 11500
4	ENGL 10600	First-Year Composition		3	COM 11400	Fundamentals of Speech Communication	
2	ENGR 13100	Tranforming Ideas to Innovation I		2	ENGR 13200	Transforming Ideas to Innovation II	ENGR 13100
4	MA 16500	Plane Analytic Geometry and Calculus I	ALEKS 75+	4	MA 16600	Plane Analytic Geometry and Calculus II	MA 16500
3	_ _ _ _ _ _ _	UCC Approved Humanities Selective		4	PHYS 17200	Modern Mechanics	MA 16500
17				**17**			
	Fall 2nd Year				**Spring 2nd Year**		
4	ABE 20100	Thermodynamics of Biological Systems I	CHM 11500, PHYS 17200	3	ABE 20200	Thermodynamics of Biological Systems II	ABE 20100
1	ABE 29000	Sophomore Seminar		3	CHE 32000	Statistical Modeling and Quality Enhancement	MA 26500
4	BIOL 11000	Fundamentals of Biology I		3	NUTR 20500 or BCHM 30700	Food science I or Biochemistry	CHM 11600 or CHM 25700
4	CHM 25700 or (CHM 25500 and CHM 25501)	Organic chemistry or (Organic chemisry I and Organic chemistry Lab I)	CHM 11500, PHYS 17200	3	MA 26500	Linear Algebra	MA 26100
4	MA 26100	Multivariate Calculus	MA 16500	3	MA 26600	Differential Equations	MA 26100
				2	_ _ _ _ _ _ _	Humanities or Social Science Selective	
				1	_ _ _ _ _ _ _	Elective	
17				**18**			
	Fall 3rd Year				**Spring 3rd Year**		
3	ABE 30100	Modeling and Computation Tools in Biological Engineering	ABE 20200, MA 26600	3	ABE 30400	Bioprocess Engineering laboratory	ABE 30300
3	ABE 30300	Applications of Physics and Chemistry to Biological Processes	ABE 20200, MA 26500, 26600	3	ABE 30800	Heat and Mass Transfer in Food and Biological Systems	ABE 30700
3	ABE 30700	Momentum Transfer in Food and Biological Systems	ABE 20200, MA 26500, 26600	3	ABE 31400	Design of Electronic Systems	MA 26200
4	BIOL 22100	Introduction to Microbiology	BIOL 11000	3	ABE 37000	Biological/Mircobial Kinetics and Reaction Engineering	MA 26200
3	_ _ _ _ _ _ _	Economics Selective		3	ABE 45700	Transport Operations in Food and Biological Engineering I	pre/co: ABE 30800
16				**15**			
	Fall 4th Year				**Spring 4th Year**		
3	ABE 46000	Sensors and Process Controls	MA 26600	3	ABE 55800	Cell and Molecular Design Principles	ABE 55700
1	ABE 49000	Professional Practice in Agricultural and Biological Engineering	ABE 29000	3	ABE 58000	Process Engineering Of Renewable Resources	ABE 37000
3	ABE 55700	Transport Operations in Food and Biological Engineering II	ABE 45700	3	_ _ _ _ _ _ _	Biological or Food science selective	
3	_ _ _ _ _ _ _	Biological or Food science Selective		3	_ _ _ _ _ _ _	Humanities or Social Science Selective	
3	_ _ _ _ _ _ _	Written or Oral Communication Selective		3	_ _ _ _ _ _ _	Humanities or Social Science Selective (30000+ level)	
13				**15**			

128 semester credits required for Bachelor of Science degree.
2.0 GPa required for Bachelor of Science degree.

Biological Engineering: Food and Biological Process Engineering

https://ag.purdue.edu/oap/Pages/major.aspx

128 credits required for graduation

	Credits	Course number	Course Title
Departmental/Program Major Courses (127 credits)			
	Required Major Courses (45 credits)		
_____	4	ABE 20100	Thermodynamics of Biological Systems I
_____	3	ABE 20200	Thermodynamics of Biological Systems II
_____	1	ABE 29000	Sophomore Seminar
_____	3	ABE 30100	Modeling and Computation tools in Biological Engineering
_____	3	ABE 30300	Applications of Physics and Chemistry to Biological Processes
_____	3	ABE 30400	Bioprocess Engineering laboratory
_____	3	ABE 30700	Momentum Transfer in Food and Biological Systems
_____	3	ABE 30800	Heat and Mass Transfer in Food and Biological Systems
_____	3	ABE 31400	Design of Electronic Systems
_____	3	ABE 37000	Biological/Microbial Kinetics and Reaction Engineering
_____	3	ABE 45700	Transport Operations in Food and Biological Engineering I
_____	3	ABE 46000	Sensors and Process Controls
_____	1	ABE 49000	Professional Practice in Agricultural and Biological Engineering
_____	3	ABE 55700	Transport Operations in Food and Biological Engineering II
_____	3	ABE 55800	Process Design for Food and Biological Systems
_____	3	ABE 58000	Process Engineering Of Renewable Resources
	Other Departmental /Program Course Requirements (82 credits) (See Advising Resources)		
_____	2	ENGR 131	Tranforming Ideas to Innovation I
_____	4	BIOL 11000	Fundamentals of Biology I
_____	4	BIOL 22100	Introduction to Microbiology
_____	4	CHM 11500	General Chemistry (satisfies Science #1 for core)
_____	4	CHM 11600	General Chemistry (satisfies Science #2 for core)
_____	4	MA 16500	Plane Analytic Geometry and Calculus I (satifies Quantitative Reasoning for core)
_____	3	CHE 3200	Statistical Modeling and Quality Enhancement
_____	4	MA 16600	Plane Analytic Geometry and Calculus II
_____	4	MA 26100	Multivariate Calculus
_____	4	PHYS 17200	Modern Mechanics
_____	4	ENGL 10600	First-Year Composition (satisfies Written Communication for core) (satisfies Information Literacy Selective for core)
_____	3	COM 11400	Fundamentals of Speech Communication (satisfies Oral Communication for core)
_____	3	_ _ _ _ _ _ _	Written or Oral Communications Selective
_____	3	_ _ _ _ _ _ _	Economics Selective (satisfies Human Culture Behavioral/Social Science for core)
_____	3	_ _ _ _ _ _ _	UCC Humanities Selective (satisfies Human Cultures Humanities for core)
_____	2	_ _ _ _ _ _ _	Humanities or Social Science Selective
_____	3	_ _ _ _ _ _ _	Humanities or Social Science Selective
_____	3	_ _ _ _ _ _ _	Humanities or Social Science Selective (30000+ level)
_____	2	ENGR 13200	Tranforming Ideas to Innovation II
_____	4	CHM 25700 or (CHM 25500 and CHM 25501)	Organic chemistry or (Organic chemisry I and Organic chemistry Lab I)
_____	3	MA 26500	Linear Algebra
_____	3	MA 26600	Differential Equations
_____	3	NUTR 20500 or BCHM 30700	Food Science I or Biochemistry
_____	6		Biological or Food Science Selective
Electives (1 credit)			
_____	1	_ _ _ _ _ _ _	Elective

University Core Requirements:

Human Cultures Humanities:	_____	*Science, Technology, and Society:*	_____
Human Cultures Behavioral/Social Science:	_____	*Written Communication:*	_____
Information Literacy:	_____	*Oral Communication:*	_____
Science #1:	_____	*Quantitative Reasoning:*	_____
Science #2:	_____		

128 semester credits required for Bachelor of Science degree.
2.0 GPa required for Bachelor of Science degree.

Pharmaceutical Processing Engineering Plan of Study

Biological Engineering: Pharmaceutical Process Engineering

https://ag.purdue.edu/oap/Pages/major.aspx

Credits	Course number	Course Title	Prerequisites	Credits	Course number	Course Title	Prerequisites
	Fall 1st Year				**Spring 1st Year**		
4	CHM 11500	General Chemistry	pre/co: calculus	4	CHM 11600	General Chemistry	CHM 11500
4	ENGL 10600	First Year Composition		3	COM 11400	Fundamentals of Speech Communication	
2	ENGR 13100	Tranforming Ideas to Innovation I		2	ENGR 13200	Transforming Ideas to Innovation II	ENGR 13100
4	MA 16500	Plane Analytic Geometry and Calculus I	ALEKS 75+	4	MA 16600	Plane Analytic Geometry and Calculus II	MA 16500
3	_ _ _ _ _ _ _	UCC Approved Humanities Selective		4	PHYS 17200	Modern Mechanics	MA 16500
17				**17**			
	Fall 2nd Year				**Spring 2nd Year**		
4	ABE 20100	Thermodynamics of Biological Systems I	CHM 11500, PHYS 17200	3	ABE 20200	Thermodynamics of Biological Systems II	ABE 20100.
1	ABE 29000	Sophomore Seminar		3	CHE 32000	Statistical Modeling and Quality Enhancement	MA 26500
4	BIOL 11000	Fundamentals of Biology I		3	BCHM 30700	Biochemistry	CHM 25700
4	CHM 25700 or (CHM 25500 and CHM 25501)	Organic chemistry or (Organic chemisry I and Organic chemistry Lab I)	CHM 11500	1	BCHM 30900	Biochemistry Laboratory	CHM 25700
4	MA 26100	Multivariate Calculus	MA 16500	3	MA 26500	Linear Algebra	MA 26100
				3	MA 26600	Differential Equations	MA 26100
17				**16**			
	Fall 3rd Year				**Spring 3rd Year**		
3	ABE 30100	Modeling and Computation Tools in Biological Engineering	ABE 20200, MA 26600	3	ABE 30400	Bioprocess Engineering laboratory	ABE 30300
3	ABE 30300	Applications of Physics and Chemistry to Biological Processes	ABE 20200, MA 26600	3	ABE 37000	Biological/Mircobial Kinetics and Reaction Engineering	BIOL 22100
3	ABE 30700	Momentum Transfer in Food and Biological Systems	ABE 20200, MA 26500, 26600	3	ABE 30800	Heat and Mass Transfer in Food and Biological Systems	ABE 30700
4	BIOL 22100	Introduction to Microbiology	BIOL 11000	3	ABE 31400	Design of Electronic Systems	MA 26200
2	_ _ _ _ _ _ _	Humanities or Social Science Selective		3	ABE 45700	Transport Operations in Food and Biological Engineering I	pre/co: ABE 30800
1	_ _ _ _ _ _ _	Elective		3	_ _ _ _ _ _ _	Economics Selective	
16				**18**			
	Fall 4th Year				**Spring 4th Year**	Cell and Molecular Design Principles	
3	ABE 46000	Sensors and Process Controls	MA 26600	3	ABE 55800	Process Design for Food and Biological Systems	ABE 55700
1	ABE 49000	Professional Practice in Agricultural and Biological Engineering	ABE 29000	3	ABE 58000	Process Engineering Of Renewal Resources	ABE 37000
3	ABE 55700	Transport Operations in Food and Biological Engineering II	ABE 45700	2	PHRM 82900	Dosage Forms II	PHRM 82800
3	PHRM 82800	Dosage Forms I	MA 16600, CHM 25600	3	_ _ _ _ _ _ _	Humanities or Social Science Selective	
3	_ _ _ _ _ _ _	Written or Oral Communication Selective		3	_ _ _ _ _ _ _	Humanities or social science selective (30000+ level)	
13				**14**			

128 semester credits required for Bachelor of Science degree.
2.0 GPa required for Bachelor of Science degree.

Biological Engineering: Pharmaceutical Process Engineering

https://ag.purdue.edu/oap/Pages/major.aspx 128 credits required for graduation

	Credits	Course number	Course Title
Departmental/Program Major Courses (126 credits)			
	Required Major Courses (45 credits)		
_____	4	ABE 20100	Thermodynamics of Biological Systems I
_____	3	ABE 20200	Thermodynamics of Biological Systems II
_____	1	ABE 29000	Sophomore Seminar
_____	3	ABE 30100	Modeling and Computation tools in Biological Engineering
_____	3	ABE 30300	Applications of Physics and Chemistry to Biological Processes
_____	3	ABE 30400	Bioprocess Engineering laboratory
_____	3	ABE 30700	Momentum Transfer in Food and Biological Systems
_____	3	ABE 30800	Heat and Mass Transfer in Food and Biological Systems
_____	3	ABE 31400	Design of Electronic Systems
_____	3	ABE 37000	Biological/Mircobial Kinetics and Reaction Engineering
_____	3	ABE 45700	Transport Operations in Food and Biological Engineering I
_____	3	ABE 46000	Sensors and Process Controls
_____	1	ABE 49000	Professional Practice in Agricultural and Biological Engineering
_____	3	ABE 55700	Transport Operations in Food and Biological Engineering II
_____	3	ABE 55800	Process Design for Food and Biological Systems
_____	3	ABE 58000	Process Engineering Of Renewable Resources
	Other Departmental /Program Course Requirements (82 credits) (See Advising Resources)		
_____	2	ENGR 13100	Tranforming Ideas to Innovation I
_____	4	BIOL 11000	Fundamentals of Biology I
_____	4	BIOL 22100	Introduction to Microbiology
_____	4	CHM 11500	General Chemistry (satisfies Science #1 for core)
_____	4	CHM 11600	General Chemistry (satisfies Science #2 for core)
_____	4	MA 16500	Plane Analytic Geometry and Calculus I (satifies Quantitative Reasoning for core)
_____	3	CHE 32000	Statistical Modeling and Quality Enhancement
_____	4	MA 16600	Plane Analytic Geometry and Calculus II
_____	4	MA 26100	Multivariate Calculus
_____	4	PHYS 17200	Modern Mechanics
_____	4	ENGL 10600	First-Year Composition (satisfies Written Communication for core) (satisfies Information Literacy Selective for core)
_____	3	COM 11400	Fundamentals of Speech Communication (satisfies Oral Communication for core)
_____	3	_ _ _ _ _ _ _	Written or Oral Communications Selective
_____	3	_ _ _ _ _ _ _	Economics Selective (satisfies Human Culture Behavioral/Social Science for core)
_____	3	_ _ _ _ _ _ _	UCC Humanities Selective (satisfies Human Cultures Humanities for core)
_____	2	_ _ _ _ _ _ _	Humanities or Social Science Selective
_____	3	_ _ _ _ _ _ _	Humanities or Social Science Selective
_____	3	_ _ _ _ _ _ _	Humanities or Social Science Selective (30000+ level)
_____	3	BCHM 30700	Biochemistry
_____	1	BCHM 30900	Biochemistry Laboratory
_____	2	ENGR 13200	Tranforming Ideas to Innovation II
_____	4	CHM 25700 or (CHM 25500 and CHM 25501)	Organic chemistry or (Organic chemisry I and Organic chemistry Lab I)
_____	3	MA 26500	Linear Algebra
_____	3	MA 26600	Differential Equations
_____	3	PHRM 82800	Dosage Forms I
_____	2	PHRM 82900	Dosage Forms II
Electives (1 credit)			
_____	1	_ _ _ _ _ _ _	Elective

University Core Requirements:

Human Cultures Humanities: _____ *Science, Technology, and Society:* _____
Human Cultures Behavioral/Social Science: _____ *Written Communication:* _____
Information Literacy: _____ *Oral Communication:* _____
Science #1: _____ *Quantitative Reasoning:* _____
Science #2: _____

128 semester credits required for Bachelor of Science degree.
2.0 GPa required for Bachelor of Science degree.

Biological Engineering Course Descriptions

Required Courses (Catalog Descriptions)

ABE 20100 Thermodynamics in Biological Systems I. Credit Hours: 4.00. Thermodynamic principles associated with biological systems and processing of biological materials. Emphasis on the first law of thermodynamics. Fundamentals of steady-state mass and energy balances for reacting and non-reacting processes including multiple unit operations emphasizing living systems and bioprocessing. Applications of the first law conservation of energy to biological systems, energy conversion systems, and the environmental impacts of energy production. Development of engineering problem solving skills via MathCad and MatLab software. Laboratory emphasizes combining technical engineering skills with professional skill development through computer and laboratory exercises including two extensive projects that result in a biological product design. Typically offered Fall. Prerequisites: (Undergraduate level CHM 11600 Minimum Grade of D- or Undergraduate level CHM 12400 Minimum Grade of D- or Undergraduate level CHM 11000 Minimum Grade of D- or Undergraduate level CHM 12600 Minimum Grade of D- or Undergraduate level CHM 13600 Minimum Grade of D-) or (Undergraduate level CHEM C1020 Minimum Grade of D- and Undergraduate level CHEM C1220 Minimum Grade of D-) or (Undergraduate level CHEM C1060 Minimum Grade of D- and Undergraduate level CHEM C1260 Minimum Grade of D-)

ABE 20200 Thermodynamics in Biological Systems II. Credit Hours: 3.00. Thermodynamic principles and their applications to biochemical and biological systems with emphasis on the second law of thermodynamics and use of molecular interpretations of energies and entropies. Concept of entropy balances and process efficiency. Free energy and chemical equilibrium. Equilibrium between phases, colligative properties, binding of ligands and formation of biological membrances. Molecular motion and transport properties and their application in biochemical analytical methods. Development of physical chemical problem solving skills using MathCad and MatLab software. Typically offered Spring. Prerequisites: Undergraduate level ABE 20100 Minimum Grade of D- and (Undergraduate level MA 26100 Minimum Grade of D- or Undergraduate level MA 17200 Minimum Grade of D- or Undergraduate level MA 17400 Minimum Grade of D- or Undergraduate level MA 27100 Minimum Grade of D- or Undergraduate level MA 26300 Minimum Grade of D- or Undergraduate level MA 18200 Minimum Grade of D-)

ABE 29000 Sophomore Seminar. Credit Hours: 3.00. Thermodynamic principles and their applications to biochemical and biological systems with emphasis on the second law of thermodynamics and use of molecular interpretations of energies and entropies. Concept of entropy balances and process efficiency. Free energy and chemical equilibrium. Equilibrium between phases, colligative properties, binding of ligands and formation of biological membrances. Molecular motion and transport properties and their application in biochemical analytical methods. Development of physical chemical problem solving skills using MathCad and MatLab software. Typically offered Spring.

ABE 30100 Modeling and Computational Tools in Biological Engineering. Credit Hours: 3.00. Introduction to principles of analysis, setup, and modeling of biological systems using fundamental principles of engineering. Development of algebraic and differential models of steady state and transient processes involving material and energy balances, elementary thermodynamic, transport, and kinetic reaction principles, and economics in biological engineering systems. Typically offered Fall Spring. Prerequisites: Undergraduate level ABE 20200 Minimum Grade of D- and (Undergraduate level MA 26200 Minimum Grade of D- or Undergraduate level MA 27200 Minimum Grade of D-) or (Undergraduate level ABE 20200 Minimum Grade of D- and (Undergraduate level MA 26500 Minimum Grade of D- or Undergraduate level MA 35100 Minimum Grade of D- or Undergraduate level MA 35000 Minimum Grade of D-) and (Undergraduate level MA 26600 Minimum Grade of D- or Undergraduate level MA 30300 Minimum Grade of D- or Undergraduate level MA 36600 Minimum Grade of D- or Undergraduate level MA 30400 Minimum Grade of D-) or (Undergraduate level MA 26600 Minimum Grade of D- or Undergraduate level MA 30300 Minimum Grade of D- or Undergraduate level MA 36600 Minimum Grade of D- or Undergraduate level MA 30400 Minimum Grade of D-) and (Undergraduate level ME 20000 Minimum Grade of D-) or Undergraduate level ME 35000 Minimum Grade of D-)

ABE 30300 Applications of Physical Chemistry to Biological Processes. Credit Hours: 3.00. Physical chemical principles associated with transport of mass, momentum and energy in bioprocesses. Principles for measuring physical chemical properties, a description of predictive equations for their evaluation and the role of these principles in the design and optimization of bioprocesses. Typically offered Fall. Prerequisites: (Undergraduate level ABE 20200 Minimum Grade of D- or Undergraduate level ME 20000 Minimum Grade of D-) and Undergraduate level CHM 25700 Minimum Grade of D- and Undergraduate level CHE 37700 Minimum Grade of D- [may be taken concurrently]

ABE 30400 Bioprocess Engineering Laboratory. Credit Hours: 3.00. Laboratory course focused on bioprocessing topics such as fluid flow, mixing, rheology, hydrolysis, and fermentation of biomaterials. Students will participate in design of experiments, system set up, data collection, statistical data analysis, and presentation of results. Typically offered Spring. Prerequisites: Undergraduate level ABE 30800 Minimum Grade of D- [may be taken concurrently]
ABE 30700 Momentum Transfer In Food And Biological Systems. Credit Hours: 3.00. Fluid statics, Newton's law of viscosity, shell momentum balances, equations of continuity and motion, one dimensional flow problems, flow through porous media, velocity distributions with more than one independent variable, two dimensional flow through a channel, stream function, velocity potential, dimensional analysis, boundary layer, turbulent flow, Reynolds stress, form and skin friction, application of macroscopic momentum and mechanical energy balances to engineering problems. Typically offered Fall. Prerequisites: Undergraduate level ABE 20200 Minimum Grade of D- and Undergraduate level MA 26500 Minimum Grade of D- and Undergraduate level MA 26600 Minimum Grade of D-
ABE 30800 Heat And Mass Transfer In Food And Biological Systems. Credit Hours: 3.00. 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 applications to the solution of practical problems in the Food Process and Biological Engineering fields. Typically offered Spring. Prerequisites: Undergraduate level ABE 30700 Minimum Grade of D-
ABE 31400 Design Of Electronic Systems. Credit Hours: 3.00. Fundamental aspects of circuits, microprocessors, transducers, sensors, instrumentation, and data acquisition are presented, with particular emphasis on electronic systems used in agricultural, biological, and food applications. Laboratory exercises used to apply the course material to constructing and testing circuits, microprocessor controlled systems, and the data collection and monitoring of systems. Typically offered Spring. Prerequisites: Undergraduate level MA 26200 Minimum Grade of D- or Undergraduate level MA 26600 Minimum Grade of D-
ABE 37000 Biological/Microbial Kinetics and Reaction Engineering. Credit Hours: 3.00. Study of the rates of chemical/biochemical reaction and catalysis in agricultural, food, and biological systems with applications to engineering process design. Applications include microbial growth, enzyme catalysis, fermentation and reactor design. Introductory enzymatic and microbial reaction concepts will be taught and incorporated into reactor design. Typically offered Spring. Prerequisites: ABE 37000-Requisites
General Requirements: (Rule: 1: ABE30100&CHM25700&BIOL22100 for a total of 3 conditions)
ABE 30100, Minimum Grade of D-, May not be taken concurrently. BIOL 22100, Minimum Grade of D-, May be taken concurrently. CHM 25700, Minimum Grade of D-, May not be taken concurrently (end of rule 1) **and** Rule: 2: MA 26200 for a total of 1 conditions MA 26200, Minimum Grade of D-, May not be taken concurrently (end of rule 2) **or** Rule: 3: MA 27200 for a total of 1 conditions MA 27200, Minimum Grade of D-, May not be taken concurrently (end of rule 3) **or** Rule: 4: MA 26500 & MA 26600 for a total of 2 conditions MA 26500, Minimum Grade of D-, May not be taken concurrently. MA 26600, Minimum Grade of D-, May not be taken concurrently (end of rule 4) **or** Rule: 5: MA 26500 & 30300 for a total of 2 conditions MA 26500, Minimum Grade of D-, May not be taken concurrently. MA 30300, Minimum Grade of D-, May not be taken concurrently (end of rule 5) **or** Rule: 6: MA 26500 & MA 30400 for a total of 2 conditions MA 26500, Minimum Grade of D-, May not be taken concurrently. MA 30400, Minimum Grade of D-, May not be taken concurrently (end of rule 6) **or** Rule: 7: MA 26500 & MA 36600 for a total of 2 conditions MA 26500, Minimum Grade of D-, May not be taken concurrently. MA 36600, Minimum Grade of D-, May not be taken concurrently (end of rule 7) **or** Rule: 8: MA 35100 & MA 30300 for a total of 2 conditions MA 30300, Minimum Grade of D-, May not be taken concurrently. MA 35100, Minimum Grade of D-, May not be taken concurrently (end of rule 8) **or** Rule: 9: MA 35100 & MA 26600 for a total of 2 conditions MA 26600, Minimum Grade of D-, May not be taken concurrently. MA 35100, Minimum Grade of D-, May not be taken concurrently (end of rule 9) **or** Rule: 10: MA 35100 & MA 30400 for a total of 2 conditions MA 30400, Minimum Grade of D-, May not be taken concurrently. MA 35100, Minimum Grade of D-, May not be taken concurrently (end of rule 10) **or** Rule: 11: MA 35100 & MA 36600 for a total of 2 conditions MA 35100, Minimum Grade of D-, May not be taken concurrently. MA 36600, Minimum Grade of D-, May not be taken concurrently (end of rule 11).
ABE 45700 Transport Operations In Food And Biological Engineering I. Credit Hours: 3.00. Application of momentum and heat transfer to biological and food process engineering. Viscosity, non-Newtonian fluids, experimental methods of rheological characterization of food and biological systems; viscoelasticity; design equations for pipe flow,

pumps, mixing, emulsification, extrusion, sheeting, heat exchanges, aseptic processing, sterilization, freezing, and evaporation. Typically offered Spring. Prerequisites: Undergraduate level ABE 30800 Minimum Grade of D-
ABE 46000 Sensors and Process Control. Credit Hours: 3.00. Fundamental aspects of transducers, biosensors, instrumentation, and computer control are presented, with particular emphasis on sensors and controls used in agricultural, biological, and food applications. Laboratory and pilot plant scale computer controlled equipment is used to examine response of process variables, sensor calibration, control system modeling, and controller selection and tuning. Prereq: differential equations and a course in either heat transfer or fluid mechanics. Typically offered Spring. Prerequisites: (Undergraduate level MA 26200 Minimum Grade of D- or Undergraduate level MA 27200 Minimum Grade of D-) or (Undergraduate level MA 26600 Minimum Grade of D- or Undergraduate level MA 30400 Minimum Grade of D- or Undergraduate level MA 36600 Minimum Grade of D- or Undergraduate level MA 30300 Minimum Grade of D-)
ABE 49000 Professional Practice in Agricultural and Biological Engineering. Credit Hours: 1.00. Career areas in agricultural engineering; job opportunities and graduate study; professional attitudes and ethics; contracts and specifications; patents. Typically offered Fall. Prerequisites: Undergraduate level ABE 29000 Minimum Grade of D-
ABE 55700 Transport Operations in Food and Biological Systems II. Credit Hours: 3.00. Analysis and design of operations, such as dehydration, fermentation, and separation processes. Development of experimental designs. Integration of pilot plant results into the design, operation and scale-up process systems. Emphasis on how the properties of biological materials influence the quality of the processed product. Typically offered Fall. Prerequisites: ABE 45700
ABE 55800 Process Design for Food and Biological Systems. Credit Hours: 3.00. The course will focus on the design, synthesis, creation, evaluation and optimization of processes to convert basic biological materials into a finished product. Concepts of materials and energy balances, thermodynamics, kinetics, transport phenomena of biological systems will be used to design processes to minimize energy and environmental impacts, and evaluate economic factors while maintaining product quality. Group projects, written and oral reports. Prerequisites: ABE 55700

ABE 58000 Process Engineering of Renewable Resources. Credit Hours: 3.00. Physical and chemical structure of biomass. Reaction kinetics of hydrolysis of hemicellulose and cellulose to fermentable sugars. Fundamentals of ethanol production by fermentation. Separation of fermentation products into pure components. Typically offered Spring. Prerequisites: GR-ABE 58000 Requisites
General Requirements: (Student Attribute: GR, May not be taken concurrently.) **or** (Course or Test: ABE 37000, May not be taken concurrently.) **or** (Course or Test: CHE 34800, May not be taken concurrently.)
BCHM 30700 Biochemistry. Credit Hours: 3.00. Introduction to the chemistry, function, and metabolism of compounds found in the living organism. Typically offered Fall Spring.
BIOL 11000 Fundamentals of Biology I. Credit Hours: 4.00. This course is designed primarily to provide an introduction to the principles of biology for students in agriculture and health sciences. Principles of biology, focusing on diversity, ecology, evolution, and the development, structure, and function of organisms. Typically offered Summer Fall.
BIOL 22100 Introduction to Microbiology. Credit Hours: 4.00. The isolation, growth, structure, function, heredity, identification, classification, and ecology of microorganisms; their role in nature; and significance to man. Not available for credit toward graduation for majors in the Department of Biological Sciences. Typically offered Fall Spring.
CHM 11500 General Chemistry. Credit Hours: 4.00. Stoichiometry; atomic structure; periodic properties; ionic and covalent bonding; molecular geometry; gases, liquids, and solids; crystal structure; thermochemistry; descriptive chemistry of metals and non-metals. Required of students majoring in science and students in engineering who are not in CHM 12300. One year of high school chemistry or one semester of college chemistry required. Typically offered Fall Spring Summer.
CHM 11600 General Chemistry. Credit Hours: 4.00. A continuation of CHM 11500. Solutions; quantitative equilibria in aqueous solution; introductory thermodynamics; oxidation-reduction and electrochemistry; chemical kinetics; qualitative analysis; further descriptive chemistry of metals and nonmetals. Typically offered Fall Spring Summer.
CHM 25700 Organic Chemistry. Credit Hours: 4.00. Introductory organic chemistry. Emphasis is on structure, nomenclature, reactions, and theory as applied to simple organic compounds. This course is designed for students who require a one semester overview in preparation for biochemistry. Not recommended for majors in the College of Science. Typically offered Fall Spring.
COM 11400 Fundamentals of Speech Communication. Credit Hours: 3.00. A study of communication theories as applied to speech; practical communicative experiences ranging from interpersonal communication and small group process through problem identification and solution in discussion to informative and persuasive speaking in standard speaker-audience situations. Typically offered Fall Spring Summer.
ENGL 10600 First-Year Composition Credit Hours: 4.00. Extensive practice in writing clear and effective prose.

Instruction in organization, audience, style, and research-based writing. Typically offered Fall Spring Summer.
ENGR 13100 Transforming Ideas to Innovation I. Credit Hours: 2.00. A partnership between Schools and Programs within the College of Engineering, introduces students to the engineering professions using multidisciplinary, societally relevant content. Developing engineering approaches to systems, generating and exploring creative ideas, and use of quantitative methods to support design decisions. Explicit model-development activities (engineering eliciting activities, EEAs) engage students in innovative thinking across the engineering disciplines at Purdue. Experiencing the process of design and analysis in engineering including how to work effectively in teams. Developing skills in project management, engineering fundamentals, oral and graphical communication, logical thinking, and modern engineering tools (e.g., Excel and MATLAB). Typically offered Fall Spring Summer.
ENGR 13200 Transforming Ideas to Innovation II. Credit Hours: 2.00. A partnership between Schools and Programs within the College of Engineering continues building on the foundation developed in ENGR 13100. Students take a more in depth and holistic approach to integrating multiple disciplines perspectives while constructing innovative engineering solutions to open-ended problems. Extending skills in project management engineering fundamentals, oral and graphical communication, logical thinking, team work, and modern engineering tools (e.g., Excel and MATLAB). Typically offered Fall Spring Summer.
MA 16500 Analytic Geometry and Calculus I. Credit Hours: 4.00. Introduction to differential and integral calculus of one variable, with applications. Conic sections. Designed for students who have had at least a one-semester calculus course in high school, with a grade of "A" or "B", but are not qualified to enter MA 16200 or 16600, or the advanced placement courses MA 17300 or 27100, or the honors calculus course MA 18100. Demonstrated competence in college algebra and trigonometry. Typically offered Fall Spring.

MA 16600 Plane Geometry and Calculus II. Credit Hours: 4.00. Continuation of MA 16500. Vectors in two and three dimensions. Techniques of integration, infinite series, polar coordinates, surfaces in three dimensions. Not open to students with credit in MA 16200. Typically offered Fall Spring.
MA 26100 Multivariate Calculus. Credit Hours: 4.00. Planes, lines, and curves in three dimensions. Differential calculus of several variables; multiple integrals. Introduction to vector calculus. Not open to students with credit in MA 17400 or 27100. Typically offered Fall Spring Summer.
MA 26500 Linear Algebra. Credit Hours: 3.00. Introduction to linear algebra. Systems of linear equations, matrix algebra, vector spaces, determinants, eigenvalues and eigenvectors, diagonalization of matrices, applications. Not open to students with credit in MA 26200, 27200, 35000 or 35100. Typically offered Fall Spring Summer.
MA 26600 Ordinary Differential Equations. Credit Hours: 3.00. First order equations, second and n'th order linear equations, series solutions, solution by Laplace transform, systems of linear equations. It is preferable but not required to take MA 26500 either first or concurrently. Not open to students with credit in MA 26200, 27200, 36000, 36100, or 36600. Typically offered Fall Spring Summer.
NUTR 20500 Food Science I. Credit Hours: 3.00. Chemical and physical composition of foods: their changes during processing, storage, and preparation. Typically offered Fall Spring.
PHYS 17200 Modern Mechanics. Credit Hours: 4.00. Introductory calculus-based physics course using fundamental interactions between atoms to describe Newtonian mechanics, conservation laws, energy quantization, entropy, the kinetic theory of gases, and related topics in mechanics and thermodynamics. Emphasis is on using only a few fundamental principles to describe physical phenomena extending from nuclei to galaxies. 3-D graphical simulations and numerical problem solving by computer are employed by the student from the very beginning. Typically offered Summer Fall Spring.

Biological or Food Science Selective

CREDIT	PREFIX	NUMBER	TITLE
3	AGRY	32000	Genetics
1	AGRY	32100	Genetics Lab
3	BIOL	23000	Biology of the Living Cell
3	BIOL	23100	Biology III: Cell Structure and Function
2	BIOL	28600	Introduction to Ecology and Evolution
3	BTNY	21100	Plants and the Environment
1	FS	36100	Food Plant Sanitation
3	FS	36200	Food Microbiology
3	FS	45300	Food Chemistry
2	NUTR	31500	Fundamentals of Nutrition
4	NUTR	45300	Food Chemistry
3	CHM	25600	Organic Chemistry II
1	CHM	25601	Organic Chemistry Lab II

Biology Selective

CREDIT	PREFIX	NUMBER	TITLE
3	AGRY	32000	Genetics
1	AGRY	32100	Genetics Laboratory
2	CNIT	22700	Bioinformatics
3	FS	36300	Food Microbiology
2	IT	22700	Biotechnology Lab II
3	BCHM	30700, 30900	Biochemistry
4	HORT	30100	Plant Physiology
4	BIOL	11000	Fundamentals of Biology I
4	BIOL	11100	Fundamentals of Biology II
3	BIOL	12100	Biology I: Diversity, Ecology, and Behavior
3	BIOL	13100	Biology II: Diversity, Development, Structure and Function
4	BIOL	22100	Microbiology
2	BIOL	23200	Laboratory in Cell Structure and Function
3	BIOL	24100	Genetics and Molecular Biology
2	BIOL	24200	Laboratory in Molecular Biology and Genetics
4	BIOL	30100	Human Anatomy and Physiology
4	BIOL	30200	Human Design: Anatomy and Physiology
4	BIOL	47800	Bioinformatics
3	BIOL	43200	Reproductive Biology
3	BIOL	43600	Neurobiology
3	BIOL	49300	Introduction to Ethology
3	BIOL	53300	Medical Microbiology
3	IPPH	47500	Biopharm & Pharmacokinetics
3	IPPH	52100	Drug Development

Engineering Selective

CREDIT	PREFIX	NUMBER	TITLE
3	ABE	31400	Design of Electronic Systems
3	ABE	45000	Finite Element Method in Design and Opt. Events
3	ABE	49500	Select Topics in Ag. & Biol. Engineering
1-3	ABE	49800	Undergraduate Research in Ag. & Biol. Engineering
1-6	ABE	49900	Honors Thesis Research
3	ABE	53100	Instrumentation and Data Acquisition
3	ABE	56000	Biosensors: Fundamentals and Applications
3	ABE	52700	Computer Models in Environmental and Natural Resources Engineering
3	BME	40100	Nonlinear Dynamics in Biological Systems
3	BME	47000	Biomolecular Engineering
3	BME	43000	Biomedical Imaging Modalities
3	BME	49500	Introduction to Computational Cell Biology (cross listed with MA 49500)
3	CHE	51700	Micro/Nanoscale Physical Processes
3	CHE	54400	Structure and Physical Behavior of Polymeric Materials
3	EEE	25000	Environmental & Ecological Engineering Systems
3	EEE	43000	Industrial Ecology and Life Cycle Analysis
3	IE	23000	Probability and Statistics in Engineering I
3	IE	33000	Probability and Statistics in Engineering II
3	IE	34300	Engineering Economics
3	ME	27000	Basic Mechanics I
3	ME	41800	Engineering of Environmental Systems and Equipment
3	MSE	23000	Structure and Properties of Materials

Science Selective

CREDIT	PREFIX	NUMBER	TITLE
3	CHM	25600	Organic Chemistry II
1	CHM	25601	Organic Chemistry Lab II