

New Curriculum or Curricular Change EFD Template



College of Engineering

Engineering Faculty Document

No.: #33-25

September 4, 2024

TO: The Engineering Faculty
FROM: The Faculty of the College of Engineering
RE: New Engineering Major in Biotechnology and Bioprocess Engineering

The Faculty of the College of Engineering, Interdisciplinary Engineering, has approved the following new Major from the College of Engineering. This action is now submitted to the Engineering Faculty with a recommendation for approval.

TITLE: Biotechnology and Bioprocess Engineering

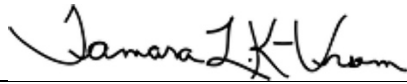
DESCRIPTION:

The Biotechnology and Bioprocess Engineering Major in Interdisciplinary Engineering Professional Masters degree is designed provide students with foundational **knowledge in quantitative analysis and process design** to solve problems related to biotechnology, bioprocess, and biomanufacturing engineering. The degree provides integrated curriculum and experiential training opportunities for students that falls outside of traditional academic unit boundaries. It is designed to meet a defined market need for the rapidly growing biotechnology and bioprocess industries, with significant industry buy-in and interest in Indiana. As a professional master's program, the curriculum is designed to provide excellent technical depth and cutting-edge professionalization experiences through industry- or faculty-sponsored project experiences or internships for practical hands-on training in their desired application areas.

The Biotechnology and Bioprocess Engineering PMP adds skills at the interface between a student's STEM background and engineering, creating hybrid graduates highly valued by industry because of both their breadth of knowledge and ability to communicate effectively across disciplines, but also their depth of knowledge in biotechnology engineering, bioprocess Engineering and advanced biomanufacturing methods.

RATIONALE:

Purdue West Lafayette Interdisciplinary Engineering presents this degree for consideration as a Hybrid degree, offered both in Indianapolis and Online. Purdue is the premier public institution in Indiana with the expertise to lead research and education efforts in Biotechnology and Bioprocess Engineering. Multiple synergistic efforts by the State of Indiana and Purdue University are emerging in Indianapolis to create vibrant ecosystem for the training of Engineering talent in Pharmaceutical Engineering (already existing PMP in Indianapolis) and Biotechnology and Bioprocess Engineering and manufacturing (this PMP). Leveraging the curricular assets that the Biotechnology and Bioprocess Engineering PMP will create, we will also offer the opportunity for working professionals to obtain key skills and knowledge in advanced biotechnology and bioprocess engineering, and manufacturing principles via Purdue Online.



Associate Dean of Graduate and Professional Education, acting as Director of Interdisciplinary Engineering Graduate Programs

* Interdisciplinary Engineering Professional Masters in Biotechnology and Bioprocess Engineering Committee: Kari Clase (ABE), Mary Speer (ABE), Julie Ji (BME), Karthik Sankar (ABE), Kurt Ristroph (ABE), Vivek Narsimmhan (ChE), William Clark (ChE), Aaron Lottes (BME), Leo Green (BME), Chien-Chi Lin (BME), Tamara Kinzer-Ursem (BME, CoE), Eric VandeVoorde (CoE)

Link to Curriculog entry:

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BIOTECHNOLOGY AND BIOPROCESS ENGINEERING DEGREE DESCRIPTION

LEARNING OUTCOMES AND ASSESSMENT

Learning Outcomes

Upon completion of the Biotechnology and Bioprocess Engineering Program, students will be able to:

1. Employ quantitative, qualitative, analytic and statistical techniques to solve problems related to biotechnology, bioprocess, and biomanufacturing engineering
2. At a functional level, design processes and advanced methodologies for the engineering and manufacturing of bioproducts.
3. Employ practical understanding of biotechnology and bioprocess design and manufacturing to ensure quality, testing, and approval of bioproducts.
4. Identify and execute ethical professional practices and make well-reasoned, ethical, and socially responsible engineering decisions in a variety of design and manufacturing scenarios.
5. Communicate effectively and employ constructive professional and interpersonal skills in project management, cross-functional collaboration, and strategic planning settings

CURRICULAR COMPONENTS

Core Courses: These courses are intended to set up Biotechnology and Bioprocess Engineering students for success for the duration of their program. Courses prepare new students with the necessary foundational concepts and technical depth to succeed in advanced technical elective courses and tailor their degree and plan of study to their professional area of focus and/or current employer.

Technical Electives: These courses provide the foundational concepts and theories that can be applied in the student's desired technical field or application area. These courses should equip students to gain significant knowledge, experience, and capability in a particular technology or technical domain directly related to a student's career goals.

Professional Electives: These courses provide additional training, expertise and practice in areas that are important to student's professional development, but that might not be specific to one technical area. Examples include technical writing, project management, product development, leadership development, scientific or technical report writing.

Curriculum Component	Courses / Examples	Credits
Core Courses*	Graduate level Math/Stats (1 course)	3
	ENGR 52700 (Note that number may change when BME reorganizes their course numbering) Engineering Principles of Biotechnology	3
	ENGR 51200 Is this number available?? : Biotechnology and Bioprocess Engineering project course (waived for co-op/internship)	3
Technical Electives	Technical Depth courses (see Appendix A)	12
Professionalization Electives	Professionalization/Specialization courses (i.e. scientific writing, business, leadership, project management, etc.) (see Appendix A)	9
Total		30

*Ethical approaches and design considerations are touched on in curriculum throughout the program, but is also addressed specifically in the ENGR 52700 and ENGR 51200 courses via embedded course modules.

NEW COURSE DEVELOPMENT

One new course ~~have been~~ is envisioned for the Biotechnology and Bioprocess Engineering program and ~~are~~ is being proposed separately to the ECC (see EFD numbers ~~XX-25, and xx-25~~). The ~~two~~ new courses ~~is~~ are:

~~ENGR 61100: Introduction to Biotechnology and Bioprocess Engineering (3 credits)~~

ENGR 651200: Biotechnology and Bioprocess Engineering project course (3 credits)

ASSESSMENT OF OUTCOMES

Progress towards achievement of the competencies required for Biotechnology and Bioprocess Engineering graduates will be assessed throughout the student's plan of study:

Competency in technical foundations will be assessed through coursework via exams, oral presentations, written reports and other artefacts demonstrating individual and team capability.

Competencies in oral and written communication will be assessed through coursework via written reports, oral presentation, team projects and other artefacts demonstrating effective communication and time and project management.

Hands-on experiential learning will be assessed through written reports and individual and team presentations, and other assessments in a project course (ENGR 61200) OR via a minimum 3 month co-op or internship experience.

TARGET STUDENT PROFILE

Students with backgrounds in engineering, technology and science can succeed in Interdisciplinary Professional M.S. Programs (PMPs). The Biotechnology and Bioprocess Engineering PMP adds skills at the interface between a student's STEM background and engineering, creating hybrid graduates highly valued by industry because of both their breadth of knowledge and ability to communicate effectively across disciplines, but also their depth of knowledge in biotechnology engineering, bioprocess engineering and advanced biomanufacturing methods.

PROGRAM ADMISSION REQUIREMENTS

To qualify for admission, applicants must hold an undergraduate degree in engineering or a related technology or science discipline (**Physics, Chemistry, Biochemistry, Biology with quantitative emphasis**), and have a minimum of two years professional experience in a relevant field.

Students need a strong foundation in the following courses prior to enrollment in order to be successful in the PMP curriculum.

- Two (2) semesters of calculus (such as Analytic Geometry, Calculus I and Calculus II (e.g. [MA 16500](#) and [MA 16600](#)))

The following courses would be helpful, but are not required.

- Differential Equations (e.g. [MA 26600](#))
- Linear Algebra (e.g. [MA 26500](#))

Minimum undergraduate degree GPA guidelines (most recent degree): 3.0 or equivalent

Professional Experience: 2 years minimum in a relevant field

If the student has an industry mentor (i.e. employer), one of their letters of recommendation should come from that industry mentor.

It is expected that an applicant's academic statement of purpose discuss their professional background and accomplishments and how this program will advance their career goals.

SIMILAR DEGREES IN THE PURDUE SYSTEM AND DISTINCTIVE ELEMENTS FOR THIS DEGREE

(descriptions paraphrased from program websites)

Agricultural and Biological Engineering - Biotechnology Innovation and Regulatory Science (BIRS)

BIRS is a carefully curated curriculum that focuses on advanced topics such as drug development, good regulatory practices, quality management, hands-on laboratory skills, and regulatory compliance. Technical concepts include quantitative thinking, good manufacturing practice (GMP) and molecular basis of manufacturing therapeutic products.

Chemical Engineering – Pharmaceutical Engineering (Concentration)

Pharmaceutical Engineering program addresses the emerging problems of pharmaceutical production with special emphasis on the purification, formulation and administration of active pharmaceutical products and the development of novel healthcare engineering approaches. Courses are designed to provide graduates with the skills to be able to design and develop pharmaceutical products and modern manufacturing processes at the systems level, ensure quality of products through design, development and control, increase the technical depth of knowledge in pharmaceutical manufacturing processes and products, as well as to communicate, negotiate, and lead within a global pharmaceutical enterprise and manage pharmaceutical organizations and people.

Chemical Engineering – Biochemical Engineering (Concentration)

This concentration in Biochemical engineering applies the combination of knowledge of living systems with engineering principles to the large scale manufacture of valuable products such as foods, pharmaceuticals, enzymes and antibodies. This concentration will prepare students with a quantitative and mechanistic understanding of biological processes based on the core areas of chemical engineering; thermodynamics, kinetics, and transport phenomena. Topics that will be covered are enzyme kinetics coupled with mass transfer, bioreactor design and operation, genetic and metabolic engineering, animal cell culture and purification of bioproducts. Students and faculty in the School of Chemical Engineering at Purdue are researching the efficient conversion of raw materials such as sugars, woody biomass or CO₂ by a wide array of processes into useful bioproducts. The design and operation of the production and separation systems for biomolecules is a significant focus of biochemical engineers. Career paths are primarily available in the food, pharmaceutical and biomedical industries.

Biomedical Engineering – Biomedical Device Development (can include Industry Immersion and Certificate in Regulatory Affairs)

The curriculum emphasizes biomedical device development, but can be tailored to support student's individual career interests. Students gain knowledge of the design and development of biomedical products and processes; sharpen their ability to make well-reasoned, ethical and socially responsible engineering decisions; increase their communication, negotiation, and leadership skills; and gain a practical understanding of regulatory processes for the healthcare industry.

The Biomedical Device Development with Industry Immersion program is designed for individuals seeking a "real-world" work experience and includes a six- to 12-month internship.

A 'Regulatory Affairs and Regulatory Science in Medical Devices Certificate' introduces students to practical regulatory affairs at both the initial approval and later compliance stages. Students gain valuable in-depth knowledge of regulatory requirements as well as guided practice with effective regulatory document submissions. This advanced education in regulatory quality, science, and compliance will prepare students for rapid integration into regulatory teams in critical areas of medical device and other related industries.

EXTERNAL COMPETITIVE DEGREES – BRIEF SUMMARY

The following are Biotechnology degrees offered at other Universities. Note that only two other Engineering focused programs exist in the market and only one Online program.

Northwestern (Engineering) [https://www.mccormick.northwestern.edu/Biotechnology and Bioprocess Engineering/](https://www.mccormick.northwestern.edu/Biotechnology_and_Bioprocess_Engineering/)

University of Pennsylvania (Collaboration between Life Sciences and Engineering) <https://biotech.seas.upenn.edu/>

University of Wisconsin (Online) [https://uwex.wisconsin.edu/applied-Biotechnology and Bioprocess Engineering#overview](https://uwex.wisconsin.edu/applied-Biotechnology_and_Bioprocess_Engineering#overview)

IU Bloomington Biotechnology and Bioprocess Engineering MS (Biology) [https://biology.indiana.edu/graduate/Biotechnology and Bioprocess Engineering/index.html](https://biology.indiana.edu/graduate/Biotechnology_and_Bioprocess_Engineering/index.html)

Johns Hopkins (Life Sciences, both online and residential) [https://advanced.jhu.edu/academics/graduate/ms-Biotechnology and Bioprocess Engineering/](https://advanced.jhu.edu/academics/graduate/ms-Biotechnology_and_Bioprocess_Engineering/)

University of Wisconsin (Life Sciences, business, residential) <https://ms-biotech.wisc.edu/#>

University of Delaware (Biological Sciences) [https://www.bio.udel.edu/graduate/current-students/professional-degrees/professional-science-masters-degree-in-Biotechnology and Bioprocess Engineering](https://www.bio.udel.edu/graduate/current-students/professional-degrees/professional-science-masters-degree-in-Biotechnology-and-Bioprocess-Engineering)

University of California Berkley (Chemistry, Bioprocess Engineering) <https://chemistry.berkeley.edu/grad/cbe/bioprocess-engineering>

SUNY College of Environmental Science and Forestry (Chemical Engineering, Bioprocess Engineering) <https://www.esf.edu/academics/graduate/bioprocessengineering.php>

CONTINUATION OF PROGRAM DEVELOPMENT AND FACULTY ENGAGEMENT

The Biotechnology and Bioprocess Engineering program has a faculty and administrative committee devoted to continuing progress on the program. Discussions and engagements after a curricular approval will include:

- Departmental collaborations
- Continued curriculum development
- Program administration and operations

Appendix A: Course Categories

Course Number	Course Title	Math / Statistics	Technical Electives	Professionalization Elective
AAE 55400	Fatigue Struct & Materials		X	
ABE 51100	Drug Development		X	
ABE 51200	Good Regulatory Practices		X	
ABE 51300	Quality Management, Audits, and Inspections		X	
ABE 51400	Documents and Dialogues of Drug Development and Registration		X	
ABE 51500	Molecular Basis in Manufacturing		X	
ABE 51600	Medical Devices and Diagnostics		X	
ABE 52700	Computer Models in Environmental And Natural Resources Engineering		X	
ABE 55700	Transport Ops in Food & Bio Sys		X	

ABE 55800	Process Design for Food & Bio Sys		X	
ABE 56000 / BME 52100	Biosensors: Fndmntls & App		X	
ABE 58000	Process Eng of Renewal Resources		X	
ABE 59100	Foundations of Research in BIRS		X	
ABE 59100	Machine Learning and Vision for IoT		X	
BCHM 53600	Biological and Structural Aspects of Drug Design		X	
BCHM 56100	General Biochemistry I		X	
BCHM 56200	General Biochemistry II		X	
BCHM 61200	Bioinformatic Analysis of Genome Scale Data		X	
BIOL 51600	Molecular Biol Cancer		X	
BIOL 51700	Molecular Biology: Proteins		X	
BIOL 52900	Bacterial Physiology		X	
BIOL 53300	Medical Microbiology		X	
BIOL 53700	Immunobiology		X	
BIOL 54100	Molecular Genetics of Bacteria		X	
BIOL 56310	Protein Bioinformatics		X	
BIOL 59500	Methods & Measurements in Biophysical Chemistry		X	
BIOL 62000	Adv Top Euk Cell Biol		X	
BIOL 64700	Membrane Proteins		X	
BME 50100 (59500)	Biostatistics	X		
BME 52100/ ABE 52100? 56000?	Biosensors: Fndmntls & App		X	
BME 53000	Bio & Med Imag Diagnostic Tech		X	
BME 54200	Cell & Tissue Mechanics		X	
BME 55100	Tissue Engineering		X	
BME 56100	Preclinical and Clinical Study Design		X	
BME 56200	Regulatory Issues Surrounding Approvals of Biomedical Devices		X	
BME 56300	Quality Systems for Regulatory Compliance		X	
BME 56400	Ethical Engineering of Medical Technologies			X
BME 58100/ ECE 52600	BioMEMS		X	
BME 59500	Bioelectronics		X	
BME 59500	Biophotonics: Fundamentals and Instrumentation		X	

BME 59500	Biophotonics: Light Tissue Interaction		X	
BME 59500	Cell & Tissue Mechanics		X	
BME 59500	Continuum Models Biomed Engr		X	
BME 59500	Deep Learning		X	
BME 59500	Point of Case Diagnostics		X	
BME 59500	Principles of Tissue Engineering		X	
BME 59500	Regenerative Biol/Tissue Repair		X	
BME 59500	Regenerative Biol/Tissue Repair		X	
BME 59500	Biophotonics		X	
BME 59500	Embedded Bioinstrumentation		X	
BME 59500	Engineering Analysis of Tissues		X	
BME 59500	Drug Delivery		X	
BME 59500	Engineering Principles of Biotechnology		X	
BME 59500	Advanced Biomedical Polymers		X	
BME 59500	Polymers for BME Applications		X	
BME 59500	Molecular and Cellular Mechanics		X	
BME 59500	Biomolecular Engineering		X	
BME 59500	Cancer Engineering		X	
BME 59500	Vascular Biomechanics		X	
BME 59500	Cellular Mechanotransduction		X	
BME 59500/ ABE 59100	Polymeric Biomaterials		X	
BME 59500/ MGMT 59000	Biomedical Entrepreneurship (Biomedship)			X
BME 64600	Deep Learning		X	
BME 68300	Polymers Pharma&Biol Systems		X	
BME 69500	Advanced Cell and Tissue Mechanics		X	
BME 69500	Deep Learning		X	
BME 69500	Frontiers In Biophotonics		X	
BME 69500	Model Based Image Processing		X	
BME 69500	Multiscale Modeling in BME		X	
BME 69500	Numerical Methods in BME		X	
BME 69500	Pediatric Medical Devices		X	
BME 69500	Biophysical Methods		X	
BME 69500 (ABE 69100)	Quantitative Systems Biology		X	
BME 69500 (BME 68300)	Polymers Biomed&Pharm Systems		X	
BME 69500/ECE 64100	Digital Image Proc II		X	

BMS 51000	Human Anatomy for BioMed Scientists/Engrs.		X	
CE 59601	Entrepreneurship & Business Strategy Engineering			X
CE 61400	Statistical and Econometric Methods I	X		X
CGT 57500/ ABE 59100	Data Visualization Tools and Applications			X
CHE 52100	Principles of Tissue Engineering		X	
CHE 52300	Engr Applications in Bio Molecules		X	
CHE 52500	Biochemical Engineering		X	
CHE 53000	Engineering Math	X		
CHE 54000	Transport Phenomena		X	
CHE 55000	Optimizatiion in ChE		X	
CHE 55100	Principles of Pharmaceutical Engr		X	
CHE 55300 (59700)	Pharma Process, Dev and Design		X	
CHE 55400	Smart Mfg in Process Industries		X	
CHE 55500	Computer Integrated Process Ops		X	
CHE 55700	Intelligent Systems in Process Engr		X	
CHE 55800	Rate Control Separation Processes		X	
CHE 59700	Engineering Applications in Marketing Mgmt		X	X
CHE 59700	Financial Analysis & Management of Projects			X
CHE 59700	Analytical Approach Healthcare Delivery		X	
CHE 59700	Data Science in ChE		X	
CHE 59700	Industrial Chem Technology		X	
CHE 59700	Stem Cell Engineering		X	
CHE 59700	Process Safety		X	
CHE 59700	Process Synthesis		X	
CHE 59700	Process Safety		X	
CHE 59700	Computational Optimization		X	
CHE 59700 (50100)	Medical Devices Dev & App		X	
CHE 62300	Separation Processes		X	
CHE 63000	Applied Mathematics for Chemical Engineers	X		
CHE 63300	Probabilistic Methods in ChE	X		
CHE 65600	Advanced Process Control		X	
CHE 69700	Metabolic Engineering		X	
CHE 69700	Adv Modeling for Catalysis Studies		X	

CHE 69700 OR CHE 53000	Statistical Methods in Chemical Engineering or Intro to Engineering Math	X		
CHM 53400	Introductory Biochem (cont from 53300)		X	
CHM 53800	Molecular Biotechnology		X	
CHM 57900	Computational Chemistry		X	
CHM 63200	Membrane: Struct/Fntn		X	
CHM 63400	Biochem Struct Aspects		X	
CHM 64800	Bioinorganic Chemistry		X	
CHM 65100	Adv Organic Chemistry		X	
CHM 65200	Synthetic Organic Chem		X	
CHM 68300	Biophysical Chemistry		X	
CHM 69600	Bio Nanotechnology		X	
CHM 69600	Chemical Biology		X	
COM 61200	Gender Communication			X
CS 50100	Computing for Science and Engr		X	
CS 51400	Numerical Analysis	X		
CS 51500	Numerical Linear Algebra	X		
CS 57800	Statistical Machine Learning	X		
CS 59000	FCS: Foundations of Computer Science		X	
CS 59000	NCDS: Numerical Computing for Data Science		X	
CS 59000 (50024)	DEII: Data Engineering II		X	
CS 59000 (50025)	FDM: Foundations of Decision Making		X	
CS 59000 (59300)	DEI1: Data Engineering I		X	
CS 59300	Machine Learning Theory		X	
ECE 50024	Machine Learning		X	
ECE 56200	Introduction to Data Management		X	
ECE 57000	Artificial Intelligence		X	
ECE 59500	Intro to Data Mining		X	
ECE 60000	Random Variables & Signals		X	
ECE 60200	Lumped System Theory		X	
ECE 60400	Electromagnetic Field Theory		X	
ECE 62900	Introduction to Neural Networks		X	
ECE 63700	Digital Image Proc I		X	
ECE 64100	Digital Image Proc II		X	
ECE 64200	Information Theory and Source Coding		X	

ECE 64500	Estimation Theory		X	
ECE 69500	Sprse Modeling Algs Stat Learn		X	
ENE 55400	Globalization Engineering		X	
ENG 51500	Advanced Professional Writing			X
ENG 60311	Medical and Healthcare Writing			X
ENG 60411	Writing Proposals and Grants			X
ENG 60511	Editing and Publishing			X
ENGR 50200	Engineering Leadership			X
ENTM 64200	Analysis of Ecological Data			X
ENTR 50000	Tech Realization (2 CR)			X
ENTR 50100	Tech Realization Workshop (2CR)			X
FNR 55800	Remote Sensing Analysis and Applications		X	
IE 53000	Quality Control			X
IE 53300	Ind Application Stat			X
IE 55800	Safety Engineering			X
IE 56600	Product Management Control			X
IE 57700	Human Factors in Engineering			X
IE 58000	Systems Simulation		X	
IE 59000	Project Management			X
IE 59000	Financial Engineering			X
IE 59000 BME 59500	Complex Systems: Theory & Applications		X	
IPPH 58300	Adv Biopharmaceutics		X	
MATH 51000	Vector Calculus	X		
MATH 51100	Linear Algebra with Applications	X		
MATH 51400	Numerical Analysis	X		
MATH 51400	Numerical Analysis	X		
MATH 52500	Intro Complex Anly	X		
MATH 52700	Advanced Mathematics for Engineers and Physicists I	X		
MATH 52700	Advanced Mathematics for Engineers and Physicists I	X		
MATH 52800	Advanced Mathematics for Engineers and Physicists II	X		
MATH 59800	Linear Algebra for Data Science	X		
MCMP 57000	Basic Principles of Chemical Action on Biological Systems		X	
ME 55600	Lubrication, Friction, & Wear		X	
ME 57500	Theory and Design of Control Systems		X	
ME 58000	Nonlinear Engr Systems		X	

ME 58100	Numerical Methods in Mechanical Engineering	X		
ME 58500	Instrumentation for Engineering Measurements		X	
ME 58700	Engineering Optics		X	
ME 61200	Continuum Mechanics		X	
ME 69700	Micro/Nanofluids		X	
MGMT 54400	Database Management Systems			X
MGMT 55500	Leading Management Diversity (2 CR)			X
MGMT 57100	Data Mine			X
MGMT 57200	Six Sigma and Quality Management			X
MGMT 58100	Big Data Technologies			X
MGMT 60000	Accounting for Managers			X
MGMT 62000	Marketing Management			X
MGMT 65000	Strategic Management			X
MGMT 65430	Negotiations in Organization (2 CR)			X
MGMT 66000	Introduction to Operations Management			X
MGMT 67000	Business Analytics			X
MGMT 68800	Developing a Global Business Strategy (2 CR)			X
MSE 59700	Mechanical Properties and Behaviors of Polymers		X	
MSE 59700	Lean Manufacturing			
OLS 58300	Coaching and Mentoring in Organizations			X
PHIL 29300DL	Ethics for Data Science			X
STAT 50600	Statistical Programming and Data Management	X		
STAT 51100	Statistical Methods	X		
STAT 51200	Applied Regression Analysis	X		
STAT 51300	Statistical Quality Control			X
STAT 51400	Design of Experiments	X		
STAT 51700	Statistical Inference	X		
STAT 51900/MAS 51900	Intro to Probability	X		

STAT 52400	Applied Multivariate Analysis	X		
STAT 52800	Into Math Stat	X		
STAT 52900	Bayesian Appl Dec Thy	X		
STAT 53200	Elem Stochastic Proc	X		
STAT 55300	Linear Model	X		
STAT 59800PS	Probability and Statistics	X		
STAT 69500	D&R Big Data High Comp Complexity	X		
SYS 50000	Perspectives on Systems			X
SYS 51000	Tools and Methodologies for Designing Systems			X
SYS 53000	Practical Systems Thinking			X
TDM 51100	Corporate Partners			X
CHE 59700	Intro to Pharmaceutical Industry			X
IPPH 58000	Physical Chemical Principles		X	
IPPH 58700	Pharmaceutical Solids		X	
ME 50500	Intermediate Heat Transfer		X	
ME 53101/53201 (TBD)	Particle, Powder & Compact Characterization		X	
MSE 51200	Powder Processing		X	