

# Chemical Engineering (BS): Biomanufacturing Sciences Concentration

The Biomanufacturing Sciences Concentration provides students with the knowledge base and hands-on skills that prepare them to quickly contribute to a biomanufacturing operation. Pharmaceuticals, vaccines, enzymes, and bio-fuels are example products. Students completing this concentration also fulfill the requirements for a Minor in Biomanufacturing.

## Plan Requirements

### First Year

Fall Semester		Hours
CH 101 or CH 103	Chemistry - A Molecular Science <sup>1</sup> or General Chemistry I for Students in Chemical Sciences	3
CH 102 or CH 104	General Chemistry Laboratory <sup>1</sup> or General Chemistry Laboratory I for Students in Chemical Sciences	1
E 101	Introduction to Engineering & Problem Solving <sup>2</sup>	1
E 115	Introduction to Computing Environments	1
MA 141	Calculus I <sup>1</sup>	4
ENG 101	Academic Writing and Research <sup>2</sup>	4
<b>Hours</b>		<b>14</b>

### Spring Semester

CH 201 or CH 203	Chemistry - A Quantitative Science <sup>2</sup> or General Chemistry II for Students in Chemical Sciences	3
CH 202 or CH 204	Quantitative Chemistry Laboratory <sup>2</sup> or General Chemistry Laboratory II for Students in Chemical Sciences	1
MA 241	Calculus II	4
PY 205 & PY 206	Physics for Engineers and Scientists I and Physics for Engineers and Scientists I Laboratory <sup>1</sup>	4
Select one of the following Economics Courses:		3
ARE 201	Introduction to Agricultural & Resource Economics	
ARE 201A	Introduction to Agricultural & Resource Economics	
EC 201	Principles of Microeconomics	
EC 205	Fundamentals of Economics	
E 102	Engineering in the 21st Century	2
<b>Hours</b>		<b>17</b>

### Second Year

Fall Semester		Hours
CH 221 or CH 225	Organic Chemistry I <sup>2</sup> or Organic Chemistry I for Students in Chemical Sciences	3
CH 222 or CH 226	Organic Chemistry I Lab <sup>2</sup> or Organic Chemistry Laboratory I for Students in Chemical Sciences	1

CHE 205	Chemical Process Principles <sup>2</sup>	4
MA 242	Calculus III <sup>2</sup>	4
PY 208 & PY 209	Physics for Engineers and Scientists II and Physics for Engineers and Scientists II Laboratory	4
BEC 220	Introduction to Drug Development and Careers in Biomanufacturing	1
<b>Hours</b>		<b>17</b>

### Spring Semester

CH 223 or CH 227	Organic Chemistry II or Organic Chemistry II for Students in Chemical Sciences	3
CH 224 or CH 228	Organic Chemistry II Lab or Organic Chemistry Laboratory II for Students in Chemical Sciences	1
CHE 225	Introduction to Chemical Engineering Analysis <sup>2</sup>	3
MA 341	Applied Differential Equations I <sup>2</sup>	3
BIO 183	Introductory Biology: Cellular and Molecular Biology	4
<b>Hours</b>		<b>14</b>

### Third Year

Fall Semester		Hours
CHE 311	Transport Processes I <sup>2</sup>	3
CHE 315	Chemical Process Thermodynamics <sup>2</sup>	3
BCH 451	Principles of Biochemistry	4
BEC 425	Molecular Biology for Biomanufacturing	2
BEC 463	Fermentation of Recombinant Microorganisms	2
<b>Hours</b>		<b>14</b>

### Spring Semester

CHE 312	Transport Processes II	3
CHE 316	Thermodynamics of Chemical and Phase Equilibria	3
BBS 426	Upstream Biomanufacturing Laboratory	2
BEC 330	Principles and Applications of Bioseparations	2
<b>Hours</b>		<b>10</b>

### Fourth Year

Fall Semester		Hours
CHE 395	Professional Development Seminar	1
CHE 446	Design and Analysis of Chemical Reactors	3
CHE 450	Chemical Engineering Design I	3
BEC 436	Introduction to Downstream Process Development	2
BEC 480 or BEC 485	cGMP Fermentation Operations or cGMP Downstream Operations	2
<b>Hours</b>		<b>11</b>

### Spring Semester

CHE 448	Bioreactor Design	2
CHE 435	Process Systems Analysis and Control	3
CHE 451	Chemical Engineering Design II	3
Biomanufacturing Elective (p. 2)		2

Bioethics Elective (p. 2)	3
<b>Hours</b>	<b>13</b>
<b>Total Hours</b>	<b>110</b>

<sup>1</sup> A grade of C or higher is required.

<sup>2</sup> A grade of C- or higher is required.

Code	Title	Hours	Counts towards
<b>GEP Courses</b>			
	GEP Humanities ( <a href="http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-humanities/">http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-humanities/</a> )	6	
	GEP Social Sciences ( <a href="http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-social-sciences/">http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-social-sciences/</a> )	3	
	GEP Health and Exercise Studies ( <a href="http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-health-exercise-studies/">http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-health-exercise-studies/</a> )	2	
	GEP Elective ( <a href="http://catalog.ncsu.edu/undergraduate/gep-category-requirements/">http://catalog.ncsu.edu/undergraduate/gep-category-requirements/</a> )	3	
	GEP Global Knowledge ( <a href="http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-global-knowledge/">http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-global-knowledge/</a> ) (verify requirement)		
	World Language Proficiency ( <a href="http://catalog.ncsu.edu/undergraduate/gep-category-requirements/world-language-proficiency/">http://catalog.ncsu.edu/undergraduate/gep-category-requirements/world-language-proficiency/</a> ) (verify requirement)		
<b>Free Electives</b>			
	Free Electives (12 Hr S/U Lmt) <sup>1</sup>	3	
<b>Total Hours</b>		<b>17</b>	

<sup>1</sup> Students should consult their academic advisors to determine which courses fill this requirement.

## Biomanufacturing Electives

Code	Title	Hours	Counts towards
BEC 445	Cell Line Development for Biomanufacturing	2	
or BEC 545	Cell Line Development for Biomanufacturing		
BEC 462	Fundamentals of Bio-Nanotechnology	3	
BEC 475	Global Regulatory Affairs for Medical Products	3	

or BEC 575	Global Regulatory Affairs for Medical Products		
BEC 480	cGMP Fermentation Operations	2	
or BEC 580	cGMP Fermentation Operations		
BEC 483	Tissue Engineering Technologies	2	
or BME 483	Tissue Engineering Technologies		
BEC 485	cGMP Downstream Operations	2	
or BEC 585	cGMP Downstream Operations		
BEC 488	Animal Cell Culture Engineering	2	
BEC 497	Biomanufacturing Research Projects	1-3	

## Bioethics Electives

Code	Title	Hours	Counts towards
IDS 201	Environmental Ethics	3	
IDS 303	Humans and the Environment	3	
NR 303	Humans and the Environment	3	
PHI 325	Bio-Medical Ethics	3	
STS 302	Contemporary Science, Technology and Human Values	3	
STS 304	Ethical Dimensions of Progress	3	
STS 325	Bio-Medical Ethics	3	

## Semester Sequence

This is a sample.

First Year		Hours
Fall Semester		
CH 101	Chemistry - A Molecular Science <sup>1</sup>	3
or CH 103	or General Chemistry I for Students in Chemical Sciences	
CH 102	General Chemistry Laboratory <sup>1</sup>	1
or CH 104	or General Chemistry Laboratory I for Students in Chemical Sciences	
E 101	Introduction to Engineering & Problem Solving <sup>1</sup>	1
E 115	Introduction to Computing Environments	1
ENG 101	Academic Writing and Research <sup>1</sup>	4

MA 141	Calculus I	4
GEP Health and Exercise Studies ( <a href="http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-health-exercise-studies/">http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-health-exercise-studies/</a> )		1
<b>Hours</b>		<b>15</b>
<b>Spring Semester</b>		
CH 201 or CH 203	Chemistry - A Quantitative Science <sup>2</sup> or General Chemistry II for Students in Chemical Sciences	3
CH 202 or CH 204	Quantitative Chemistry Laboratory or General Chemistry Laboratory II for Students in Chemical Sciences	1
MA 241	Calculus II <sup>1</sup>	4
PY 205	Physics for Engineers and Scientists I <sup>1</sup>	3
PY 206	Physics for Engineers and Scientists I Laboratory <sup>1</sup>	1
E 102	Engineering in the 21st Century	2
GEP Health and Exercise Studies ( <a href="http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-health-exercise-studies/">http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-health-exercise-studies/</a> )		1
<b>Hours</b>		<b>15</b>
<b>Second Year</b>		
<b>Fall Semester</b>		
BEC 220	Introduction to Drug Development and Careers in Biomanufacturing	1
CH 221 or CH 225	Organic Chemistry I <sup>2</sup> or Organic Chemistry I for Students in Chemical Sciences	3
CH 222 or CH 226	Organic Chemistry I Lab or Organic Chemistry Laboratory I for Students in Chemical Sciences	1
CHE 205	Chemical Process Principles	4
MA 242	Calculus III	4
PY 208	Physics for Engineers and Scientists II	3
PY 209	Physics for Engineers and Scientists II Laboratory	1
<b>Hours</b>		<b>17</b>
<b>Spring Semester</b>		
BIO 183	Introductory Biology: Cellular and Molecular Biology	4
CH 223 or CH 227	Organic Chemistry II or Organic Chemistry II for Students in Chemical Sciences	3
CH 224 or CH 228	Organic Chemistry II Lab or Organic Chemistry Laboratory II for Students in Chemical Sciences	1
CHE 225	Introduction to Chemical Engineering Analysis <sup>2</sup>	3
MA 341	Applied Differential Equations I <sup>2</sup>	3
Select one of the following:		3
EC 205	Fundamentals of Economics	
EC 201	Principles of Microeconomics	
ARE 201	Introduction to Agricultural & Resource Economics	
<b>Hours</b>		<b>17</b>

**Third Year****Fall Semester**

BCH 451	Principles of Biochemistry	4
BEC 425	Molecular Biology for Biomanufacturing	2
BEC 463	Fermentation of Recombinant Microorganisms	2
CHE 311	Transport Processes I <sup>1</sup>	3
CHE 315	Chemical Process Thermodynamics <sup>1</sup>	3
GEP Requirement ( <a href="http://catalog.ncsu.edu/undergraduate/gep-category-requirements/">http://catalog.ncsu.edu/undergraduate/gep-category-requirements/</a> )		3

---

**Hours** **17**

**Spring Semester**

BEC 426	Upstream Biomanufacturing Laboratory	2
BEC 330	Principles and Applications of Bioseparations	2
CHE 312	Transport Processes II	3
CHE 316	Thermodynamics of Chemical and Phase Equilibria	3
Free Elective		3
GEP Requirement ( <a href="http://catalog.ncsu.edu/undergraduate/gep-category-requirements/">http://catalog.ncsu.edu/undergraduate/gep-category-requirements/</a> )		3

---

**Hours** **16**

**Fourth Year****Fall Semester**

BEC 436	Introduction to Downstream Process Development	2
BEC 480 or BEC 485	cGMP Fermentation Operations or cGMP Downstream Operations	2
CHE 395	Professional Development Seminar	1
CHE 446	Design and Analysis of Chemical Reactors	3
CHE 450	Chemical Engineering Design I	3
GEP Requirement ( <a href="http://catalog.ncsu.edu/undergraduate/gep-category-requirements/">http://catalog.ncsu.edu/undergraduate/gep-category-requirements/</a> )		3

---

**Hours** **14**

**Spring Semester**

Biomanufacturing Elective (p. 2)		2
CHE 448	Bioreactor Design	2
CHE 435	Process Systems Analysis and Control	3
CHE 451	Chemical Engineering Design II	3
Bioethics Elective (p. 2)		3
GEP Requirement ( <a href="http://catalog.ncsu.edu/undergraduate/gep-category-requirements/">http://catalog.ncsu.edu/undergraduate/gep-category-requirements/</a> )		3

---

**Hours** **16**

---

**Total Hours** **127**

<sup>1</sup> A grade of C or higher is required.

<sup>2</sup> A grade of C- or higher is required.

## Career Opportunities

Careers in chemical engineering are sometimes exciting, always demanding, and ultimately provide a sense of accomplishment and achievement. Graduates find employment in sub-disciplines such as production, technical service, sales, management and administration; research and development; and consulting and teaching. Students

desiring careers in teaching, research, or consulting are encouraged to continue their education and pursue a graduate degree (consult the Graduate Catalog). The undergraduate curriculum also provides strong preparation for graduate study in a wide range of professional specialties, and chemical engineering graduates often pursue careers in the medical sciences, business management, and law.

## Career Titles

- Agricultural Engineer
- Automotive Engineer
- Biochemist
- Biomedical Engineer
- Chemical Engineer
- Chemist
- Dairy Technologist
- Electronics Engineer
- Engineering Professor
- Environmental Engineer
- Fire Prevention Engineer
- Industrial Air Pollution Analyst
- Industrial Waste Inspector
- Laboratory Tester
- Materials Engineer
- Materials Scientist
- Nanosystems Engineers
- Non-Destructive Testing Specialists
- Nuclear Engineer
- Nuclear Fuels Research Engineer
- Occupational Safety & Health Inspector
- Perfumer
- Petroleum Engineer
- Physicist
- Physics Professor
- Product Safety Engineer
- Quality Control Managers
- Radiation Protection Engineer
- Safety Inspector
- Sales Engineers
- Sales Representative (Chemicals & Drugs)
- Soil Engineer
- Solar Energy Systems Engineers
- Sustainability Specialists
- Toxicologist
- Water/Wastewater Engineers

## Learn More About Careers

NCcareers.org (<https://nccareers.org/>)

Explore North Carolina's central online resource for students, parents, educators, job seekers and career counselors looking for high quality job and career information.

Occupational Outlook Handbook (<https://www.bls.gov/ooh/>)

Browse the Occupational Outlook Handbook published by the Bureau of Labor Statistics to view state and area employment and wage statistics.

You can also identify and compare similar occupations based on your interests.

Career One Stop Videos (<https://www.careeronestop.org/>)

View videos that provide career details and information on wages, employment trends, skills needed, and more for any occupation. Sponsored by the U.S. Department of Labor.

Focus 2 Career Assessment (<https://careers.dasa.ncsu.edu/explore-careers/career-assessments/>) (NC State student email address required)  
This career, major and education planning system is available to current NC State students to learn about how your values, interests, competencies, and personality fit into the NC State majors and your future career. An NC State email address is required to create an account. Make an appointment with your career counselor (<https://careers.dasa.ncsu.edu/about/hours-appointments/>) to discuss the results.

Focus 2 Apply Assessment (<https://www.focus2career.com/Portal/Register.cfm?SID=1929>) (Available to prospective students)  
A career assessment tool designed to support prospective students in exploring and choosing the right major and career path based on your unique personality, interests, skills and values. Get started with Focus 2 Apply and see how it can guide your journey at NC State.

American Institute of Chemical Engineers (<https://www.aiche.org/>)  
American Chemical Society (<https://www.acs.org/>)  
American Oil Chemists' Society (<http://www.aocs.org/>)  
National Society of Professional Engineers (<https://www.nspe.org/>)