

BIOLOGICAL ENGINEERING (BIOE)

College of Engineering

Biological engineering integrates a strong engineering and technology foundation with biological, chemical, pharmaceutical, and environmental principles. Our interdisciplinary curriculum prepares engineers with specialized expertise to design and analyze new and sustainable ways to produce safe and abundant food, develop innovative environmental solutions for agricultural and urban waste management, and life-enhancing and life-saving products. Sample Careers: process and product engineer, research and development specialist, engineering consultant.

Learning Outcomes

By the end of the Biological Engineering major, graduates will be able to:

- **Problem Solving and Critical Thinking:** Develop ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, and life sciences.
- **Breadth and Depth of Understanding:** Understand the physical, chemical, and mathematical basis of biological, biochemical, and environmental systems.
- **Communication:** Effectively communicate engineering and scientific data with appropriate rationale to a range of audiences.
- **Methodology and Techniques:** Design and implement engineering solutions to problems of biological, biochemical, environmental, and social importance.
- **Professional and Ethical Behaviour:** Develop and demonstrate effective ethical, teamwork, cooperation, and life-long learning skills.

Areas of Emphasis Learning Outcomes

Biochemical Engineering

- Understand concepts of bioprocessing, bioinformatics, and immunology leading to pharmaceutical and biotechnological product development and discovery dynamics, common manufacturing technologies and economic and regulatory contexts.
- Apply the concepts of physical, biochemical, immunological and biological sciences, for the design of interdisciplinary engineering solutions for optimized pharmaceutical and biotechnological processes.

Environmental Engineering

- Develop ability to identify, evaluate and formulate sustainable engineering solutions to air-, water-, and soil-related problems in natural and engineering systems.
- Apply the concepts of chemistry, water and wastewater treatment, biological waste management and air pollution to improve environmental sustainability.

Food Engineering

- Develop ability to identify, evaluate and formulate sustainable interdisciplinary engineering solutions to solve complex problems in food industry. #FE1
- Apply the concepts of basic sciences, mathematics, and engineering to convert agricultural commodities to edible foods using food unit operations, processes, and practices to meet industrial quality standards.

Major Requirements (Honours)

This is a major within the degree: Bachelor of Engineering.

Credit Summary (22.00 Total Credits)

Code	Title	Credits
Required Core Courses		18.00
Area of Emphasis		2.50
Complementary Studies Electives ¹		1.50
Total Credits		22

¹ Consult BENG degree overview page for a full list of courses eligible for Complementary Studies Electives.

All students are admitted into the Co-op stream. Students who withdraw from the Co-op stream must speak with their Academic Advisor about completing the other program requirements. At least one summer academic semester will be required for students who complete the non-Co-op stream.

Core Courses

Code	Title	Credits
BIOC*2580	Introduction to Biochemistry	0.50
BIOL*1090	Introduction to Molecular and Cellular Biology	0.50
CHEM*1040	General Chemistry I	0.50
CHEM*1050	General Chemistry II	0.50
CIS*1500	Introduction to Programming	0.50
ENGG*1100	Engineering and Design I	0.75
ENGG*1210	Engineering Mechanics I	0.50
ENGG*1500	Engineering Analysis	0.50
ENGG*2010	Introduction to Biological Engineering	0.50
ENGG*2100	Engineering and Design II	0.75
ENGG*2120	Material Science	0.50
ENGG*2230	Fluid Mechanics	0.50
ENGG*2400	Engineering Systems Analysis	0.50
ENGG*2450	Electric Circuits	0.50
ENGG*3010	Introduction to Bioprocess Engineering	0.50
ENGG*3020	Heat and Mass Transfer in Biological and Bioenvironmental Systems	0.50
ENGG*3100	Engineering and Design III	0.75
ENGG*3240	Engineering Economics	0.50
ENGG*3260	Thermodynamics	0.50
ENGG*3440	Process Control	0.50
ENGG*3450	Electronic Devices	0.50
ENGG*4000	Proposal for Engineering Design IV	0.00
ENGG*4010	Unit Operations	0.50
ENGG*4110	Biological Engineering Design IV	1.00
ENGG*4380	Bioreactor Design	0.75
HIST*1250	Science and Technology in a Global Context	0.50
MATH*1200	Calculus I	0.50
MATH*1210	Calculus II	0.50
MATH*2130	Numerical Methods	0.50
MATH*2270	Applied Differential Equations	0.50

MICR*2420	Introduction to Microbiology and Immunity	0.50
PHYS*1010	Introductory Electricity and Magnetism	0.50
PHYS*1130	Physics with Applications	0.50
STAT*2120	Probability and Statistics for Engineers	0.50

Areas of Emphasis

Students registered in the BIOE major are required to complete one of the following Areas of Emphasis. Only one Area of Emphasis may be declared. Each Area of Emphasis is 2.50 credits from a single field of study. Students are encouraged to speak with an Academic Advisor when choosing an Area of Emphasis. An Area of Emphasis must be declared prior to the commencement of Semester 5.

Note: A major in Biological Engineering with a Food Engineering Area of Emphasis cannot be combined with a minor in Food Engineering.

Note: A major in Biological Engineering with an Environmental Engineering Area of Emphasis cannot be combined with a minor in Environmental Engineering.

Biochemical Engineering

Code	Title	Credits
Select at least 2.50 credits from:		
BIOC*3560	Structure and Function in Biochemistry	0.50
BIOL*3300	Applied Bioinformatics	0.50
ENGG*3700	Optimization for Engineers	0.50
ENGG*4390	Bio-instrumentation Design	0.75
MBG*2040	Foundations in Molecular Biology and Genetics	0.50
MICR*3230	Immunology	0.50

Environmental Engineering

Code	Title	Credits
Select at least 2.50 credits from:		
ENGG*3180	Air Quality	0.50
ENGG*3590	Water Quality	0.50
ENGG*4050	Quality Control	0.50
ENGG*4070	Life Cycle Assessment for Sustainable Design	0.50
ENGG*4340	Solid and Hazardous Waste Management	0.50
ENGG*4760	Biological Wastewater Treatment Design	0.50
ENVS*2270	Impacts of Climate Change	0.50
GEOG*3320	Food Systems: Issues in Security and Sustainability	0.50

Food Engineering

Code	Title	Credits
ENGG*4020	Engineering Sustainability in Food and Agriculture	0.50
ENGG*4300	Food Processing Engineering Design	0.50

Select an additional 1.50 credits from:

<i>Processing and Operations Management</i>		
ENGG*4050	Quality Control	0.50
ENGG*4070	Life Cycle Assessment for Sustainable Design	0.50

Processing, Nutrition and Packaging

FOOD*4070	Food Packaging	0.50
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FOOD*4090	Functional Foods and Nutraceuticals	0.50
NUTR*3210	Fundamentals of Nutrition	0.50

Co-op Requirements (Honours)

This is a major within the degree: Bachelor of Engineering.

The Co-op program in Biological Engineering is a five year program, including five work terms. Students must follow the academic work schedule as outlined below (also found on the Co-operative Education website: <https://www.recruitguelph.ca/cecs/>).

Academic and Co-op Work Term Schedule

Year	Fall	Winter	Summer
1	Academic Semester 1	Academic Semester 2	Off
2	Academic Semester 3 COOP*1100	Academic Semester 4	COOP*1000 Work Term I
3	COOP*2000 Work Term II	Academic Semester 5	Academic Semester 6
4	COOP*3000 Work Term III	COOP*4000 Work Term IV	COOP*5000 Work Term V
5	Academic Semester 7	Academic Semester 8	N/A

Please refer to the Co-operative Education program policy with respect to work term performance grading, work term report grading and program completion requirements.

For additional program information students should consult with their Co-op Coordinator and Co-op Faculty Advisor, listed on the Co-operative Education web site.

Credit Summary

(24.50 Total Credits)

Code	Title	Credits
Required Core Courses		18.00
One of three Areas of Emphasis		2.50
Complementary Studies Electives		1.50
Co-op Work Terms		2.50
Total Credits		24.5

Recommended Program Sequence

This major also requires the completion of an area of emphasis as listed. Students are encouraged to speak with an Academic Advisor when choosing an Area of Emphasis. An Area of Emphasis must be declared prior to the commencement of Semester 5.

Note: A major in Biological Engineering with an Food Engineering Area of Emphasis cannot be combined with a minor in Food Engineering.

Note: A major in Biological Engineering with an Environmental Engineering Area of Emphasis cannot be combined with a minor in Environmental Engineering.

Code	Title	Credits
Semester 1 - Fall		
CHEM*1040	General Chemistry I	0.50

ENGG*1100	Engineering and Design I	0.75
ENGG*1500	Engineering Analysis	0.50
MATH*1200	Calculus I	0.50
PHYS*1130	Physics with Applications	0.50

Semester 2 - Winter

CHEM*1050	General Chemistry II	0.50
CIS*1500	Introduction to Programming	0.50
ENGG*1210	Engineering Mechanics I	0.50
MATH*1210	Calculus II	0.50
PHYS*1010	Introductory Electricity and Magnetism	0.50

Semester 3 - Fall

BIOL*1090	Introduction to Molecular and Cellular Biology	0.50
COOP*1100	Introduction to Co-operative Education	0.00
ENGG*2010	Introduction to Biological Engineering	0.50
ENGG*2120	Material Science	0.50
ENGG*2230	Fluid Mechanics	0.50
MATH*2270	Applied Differential Equations	0.50
STAT*2120	Probability and Statistics for Engineers	0.50

Semester 4 - Winter

BIOC*2580	Introduction to Biochemistry	0.50
ENGG*2100	Engineering and Design II	0.75
ENGG*2400	Engineering Systems Analysis	0.50
ENGG*2450	Electric Circuits	0.50
MATH*2130	Numerical Methods	0.50
MICR*2420	Introduction to Microbiology and Immunity	0.50

Summer Semester

COOP*1000	Co-op Work Term I	0.50
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Fall Semester

COOP*2000	Co-op Work Term II	0.50
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Semester 5 - Winter

ENGG*3010	Introduction to Bioprocess Engineering	0.50
ENGG*3020	Heat and Mass Transfer in Biological and Bioenvironmental Systems	0.50
ENGG*3260	Thermodynamics	0.50
ENGG*3450	Electronic Devices	0.50
HIST*1250	Science and Technology in a Global Context	0.50

0.50 Area of Emphasis or restricted elective	0.50
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Semester 6 - Summer

ENGG*3100	Engineering and Design III	0.75
ENGG*3240	Engineering Economics	0.50
ENGG*3440	Process Control	0.50

0.50 Area of Emphasis or restricted electives	0.50
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Fall Semester

COOP*3000	Co-op Work Term III	0.50
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Winter Semester

COOP*4000	Co-op Work Term IV	0.50
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Summer Semester

COOP*5000	Co-op Work Term V	0.50
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Semester 7 - Fall

ENGG*4000	Proposal for Engineering Design IV	0.00
ENGG*4010	Unit Operations	0.50

2.00 Area of Emphasis or restricted electives	2.00
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Semester 8 - Winter

ENGG*4110	Biological Engineering Design IV	1.00
ENGG*4380	Bioreactor Design	0.75

1.00 Area of Emphasis or restricted electives	1.00
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Restricted Electives

The Engineering Program requires Biological Engineering students to complete the following combination of elective credits to complete their program.

- 2.50 credits from an Area of Emphasis
- 1.50 credits from Complementary Studies electives.

Areas of Emphasis

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Biochemical Engineering

Code	Title	Credits
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BIOL*3300	Applied Bioinformatics	0.50
ENGG*3700	Optimization for Engineers	0.50
ENGG*4390	Bio-instrumentation Design	0.75
MBG*2040	Foundations in Molecular Biology and Genetics	0.50
MICR*3230	Immunology	0.50

Environmental Engineering

Code	Title	Credits
Select at least 2.50 credits from:		
ENGG*3180	Air Quality	0.50
ENGG*3590	Water Quality	0.50
ENGG*4050	Quality Control	0.50
ENGG*4070	Life Cycle Assessment for Sustainable Design	0.50
ENGG*4340	Solid and Hazardous Waste Management	0.50
ENGG*4760	Biological Wastewater Treatment Design	0.50
ENVS*2270	Impacts of Climate Change	0.50
GEOG*3320	Food Systems: Issues in Security and Sustainability	0.50

Food Engineering

Code	Title	Credits
ENGG*4020	Engineering Sustainability in Food and Agriculture	0.50
ENGG*4300	Food Processing Engineering Design	0.50
Select an additional 1.50 credits from:		
<i>Processing and Operations Management</i>		
ENGG*4050	Quality Control	0.50
ENGG*4070	Life Cycle Assessment for Sustainable Design	0.50
FARE*3310	Operations Management	0.50
<i>Processing, Nutrition and Packaging</i>		

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FOOD*4070	Food Packaging	0.50
FOOD*4090	Functional Foods and Nutraceuticals	0.50
NUTR*3210	Fundamentals of Nutrition	0.50