Department of Biomedical Engineering

Keith E. Cook, Department Head and The David Edward Schramm Professor

Jana Kainerstorfer, Associate Department Head for Faculty and Graduate Affairs

Location: Scott Hall 4N201
www.cmu.edu/bme (http://www.cmu.edu/bme/)

Biomedical Engineering Overview

Biomedical Engineering education at Carnegie Mellon University reflects the belief that a top biomedical engineer must be deeply trained in both a traditional engineering practice and biomedical sciences. The unique additional major in Biomedical Engineering program leverages extensive collaborations with sister departments in the College of Engineering and with major medical institutions in Pittsburgh. This collaborative approach, combined with a rigorous engineering education, confers unique depth and breadth to the education of Biomedical Engineering graduates. The Biomedical Engineering department also offers an additional major in Biomedical Technology, which is open to all non-engineering students who want training beyond the Biomedical Engineering minor. The additional major curricula, demanding but readily feasible to complete in four years, are highly rewarding to motivated students.

Additional Major in Biomedical Engineering (BME) for Engineering Majors

Students who elect Biomedical Engineering as a major ***must also declare a major in one of the traditional engineering disciplines.*** The Biomedical Engineering additional major program takes advantage of curricular overlaps between Biomedical Engineering and primary Engineering majors, such that the additional major can be completed in four years with only a modest increase in course requirements. The requirements for Biomedical Engineering additional major program consist of the core, the tracks, and the capstone design course. The core exposes students to basic facets of biomedical engineering to lay a foundation. The tracks allow students to build depth in a specific aspect of biomedical engineering. The capstone design (https://www.cmu.edu/bme/Academics/undergraduate-programs/Resources/undergrad_design.html) project engages students in teamwork to develop real-world devices and technologies. *The additional major in Biomedical Engineering should be declared at the same time when declaring a traditional engineering major.*

Additional Major in Biomedical Technology (BMT) for Non-engineering Majors

The Biomedical Technology major is ***open to all non-engineering students***. Biomedical Technology is for students from non-engineering majors who want Biomedical Engineering training beyond the BME minor. The requirements for the Biomedical Technology additional major program consist of the core, the tracks, and the capstone design course. The core exposes students to basic facets of biomedical engineering to lay a foundation. The tracks allow students to build depth in a specific aspect of biomedical engineering. The capstone design (https://www.cmu.edu/bme/Academics/undergraduate-programs/Resources/undergrad_design.html) project engages students in teamwork to develop real-world applications. *The additional major in Biomedical Technology should be declared at the same time when declaring a primary major or by the second semester of the first year.*

Minor in Biomedical Engineering

The minor program is designed for students who desire exposure to biomedical engineering but may not have the time to pursue the Biomedical Engineering additional major. The program is ***open to students of all colleges*** and is popular among both engineering and science majors. In conjunction with other relevant courses, the program may provide a sufficient background for jobs or graduate studies in biomedical engineering. Students interested in a medical career may also find this program helpful.

Additional Major in Biomedical Engineering (BME) for Engineering Majors

PROGRAM REQUIREMENTS

Students who elect Biomedical Engineering (BME) as a major ***must also declare a major in one of the traditional engineering disciplines:*** Chemical Engineering, Civil Engineering, Electrical & Computer Engineering, Environmental Engineering, Materials Science & Engineering, or Mechanical Engineering. Students majoring in Biomedical Engineering must meet **three** sets of requirements: 1) Biomedical Engineering, 2) Primary Major, and 3) General Education. The Quality Point Average (QPA) for courses that count toward the additional major must be 2.00 or better. No course taken on a pass/fail or audit basis may be counted towards the additional major. *The additional major should be declared at the same time when declaring a primary major or by the second semester of the first year.*

Minimum units required for additional major (Core Courses + Track Electives): 93 - 102

Core Courses

All core courses are required.

		Units
03-121	Modern Biology	9
or 03-151	Honors Modern Biology	
42-101	Introduction to Biomedical Engineering	12
42-201	Professional Issues in Biomedical Engineering	3
42-202	Physiology	9
42-203	Biomedical Engineering Laboratory [#]	9
42-302	Biomedical Engineering Systems Modeling and Analysis	9
42-401	Foundation of BME Design [*]	6
42-402	BME Design Project	9
Total units of Core Courses		**66**

[#] Also known as 03-206 for Health Professions Program (http://www.cmu.edu/hpp/) students.
[*] 42-401 serves as the precursor/pre-requisite for 42-402 BME Design Project.

Track Electives

Completion of ***one track*** is required. See **Tracks for BME/BMT Major** for Track Elective lists.

		Units
42-XXX	Required Elective from the selected track	9 - 12
XX-XXX	Required or Additional Elective from the selected track	9 - 12
XX-XXX	Required or Additional Elective from the selected track	9 - 12
Total units of Track Electives		**27-36**

Additional Major in Biomedical Technology (BMT) for Non-Engineering Majors

PROGRAM REQUIREMENTS

The Biomedical Technology (BMT) major is ***open to all non-engineering students***. The Biomedical Technology is for students from non-engineering majors who want Biomedical Engineering training beyond the BME minor. Students majoring in Biomedical Technology must meet **three** sets of requirements: 1) Biomedical Technology, 2) Primary Major, and 3) General Education. The Quality Point Average (QPA) for courses that count toward the additional major must be 2.00 or better. No course taken on a pass/fail or audit basis may be counted towards the additional

major. *The additional major should be declared at the same time when declaring a primary major or by the second semester of the first year.*

Minimum units required for additional major (Core Courses + Track Electives): 84 - 93

Core Courses

All core courses are required.

		Units
03-121	Modern Biology	9
or 03-151	Honors Modern Biology	
42-101	Introduction to Biomedical Engineering	12
42-201	Professional Issues in Biomedical Engineering	3
42-202	Physiology	9
42-203	Biomedical Engineering Laboratory [#]	9
42-401	Foundation of BME Design [*]	6
42-402	BME Design Project	9
Total units of Core Courses		**57**

[#] Also known as 03-206 for Health Professions Program (http://www.cmu.edu/hpp/) students.
* 42-401 serves as the precursor/pre-requisite for 42-402 BME Design Project.

Track Electives

Completion of ***one track*** is required. See **Tracks for BME/BMT Major** for Track Elective lists.

		Units
42-XXX	Required Elective from the selected track	9 - 12
XX-XXX	Required or Additional Elective from the selected track	9 - 12
XX-XXX	Required or Additional Elective from the selected track	9 - 12
Total units of Track Electives		**27-36**

Minor in Biomedical Engineering

Kristin Kropf, *Undergraduate Program and Alumni Relations Coordinator, Biomedical Engineering*
Email: kgaluska@andrew.cmu.edu
https://www.cmu.edu/bme/Academics/undergraduate-programs/minor.html

The minor program is designed for students who desire exposure to biomedical engineering but may not have the time to pursue the Biomedical Engineering additional major. The program is open to students of **all** colleges and is popular among both engineering and science majors. In conjunction with other relevant courses, the program may provide a sufficient background for jobs or graduate studies in biomedical engineering. Students interested in a medical career may also find this program helpful.

The Biomedical Engineering minor curriculum is comprised of three core courses and three electives. The Quality Point Average (QPA) for courses that count toward the minor must be 2.00 or better. No course taken on a pass/fail or audit basis may be counted towards the minor.

Students who have questions or are interested in declaring Biomedical Engineering minor should contact Kristin Kropf (kgaluska@andrew.cmu.edu).

PROGRAM REQUIREMENTS

Minimum units required for minor: 57

03-121	Modern Biology	9
or 03-151	Honors Modern Biology	
42-101	Introduction to Biomedical Engineering	12
42-202	Physiology	9
42-xxx	BME Elective I	9-12
42-xxx	BME Elective II	9-12
42-xxx	BME Elective III	9-12

A BME Elective is defined as one of the following:

1. One semester of 42-200 Sophomore BME Research Project, 42-300 Junior BME Research Project, 42-400 Senior BME Research Project or 39-500 Honors Research Project. The project must be supervised by a core or courtesy Biomedical Engineering faculty member and for 9 or more units. Research projects supervised by a courtesy Biomedical Engineering faculty member must have significant biomedical engineering relevance. Note that BME Research Project can only be count as one BME elective.
2. 42-203 BME Laboratory (or the cross-listed version 03-206 for students in the Health Professions Program). Please note that priority for enrollment in 42-203 or 03-206 will be given to students who have declared the Additional Major in Biomedical Engineering. If sufficient room in the course remains after all majors have been accommodated in a given semester, students who have declared the Biomedical Engineering Designated Minor will be given the next priority for enrollment. If space still allows, other students will be enrolled.
3. Any 42-xxx course with a course number greater than 42-300 and worth at least 9 units (excluding 42-300 and 42-400- see previous comment regarding BME Research Project).

Note that non-BME, track elective courses for BME major do not automatically qualify as BME minor electives. Students can petition the Biomedical Engineering Undergraduate Affairs Committee to count non-BME classes that have significant biological/medical *and* engineering contents towards the minor requirements. The course petition form can be found here (https://www.cmu.edu/bme/Academics/undergraduate-programs/advising.html#ug-course-petition).

Biomedical Engineering/Technology Tracks

Completion of one track is required. † Denotes tracks that are not offered to Classes of 2027+.

- Biomechanics (BMEC (p. 2))
- Biomedical Devices (BMDV (p. 3))
- Biomedical Signal and Image Processing (BSIP (p. 3))
- Neuroengineering (Neuro (p. 4))
- Tissue and Cell Biotherapeutics (TCB (p. 4))
- Biomaterials and Tissue Engineering (BMTE (p. 5)) †
- Cellular and Molecular Biotechnology (CMBT (p. 5)) †
- Self-Designed Biomedical Engineering (SBME (p. 5))

Biomechanics (BMEC) Track

OVERVIEW

The BMEC track addresses the application of solid or fluid mechanics to biological and medical systems. It provides quantitative understanding of the mechanical behavior of molecules, cells, tissues, organs, and whole organisms. The field has seen a wide range of applications from the optimization of tissue regeneration to the design of surgical and rehabilitation devices.

TARGETS

The BMEC track is ideally suited to the combined education of Biomedical Engineering and Mechanical Engineering or Civil & Environmental Engineering. Both provide the necessary foundation in the underlying physical principles and their non-Biomedical Engineering applications. This track may also appeal to students of Electrical & Computer Engineering who are interested in biomedical robotics. Education in biomechanics enables students to pursue careers in medical devices or rehabilitation engineering.

REQUIREMENTS

In addition to the Biomedical Engineering core courses, students in the BMEC Track must take must take the following combination of **three** courses:

- One (1) **Required** BMEC Elective
- Two (2) BMEC Electives (either **Required** or **Additional**)

BMEC ELECTIVES

Required BMEC Electives (must take at least one of the following)

42-649/24-664	Introduction to Biomechanics	12
42-648/	Cardiovascular Mechanics	12
42-645/24-655	Cellular Biomechanics	9
42-691/24-663	Biomechanics of Human Movement	12

Additional BMEC Electives

42-641	Rehabilitation Engineering	9
42-640/24-658	Image-Based Computational Modeling and Analysis	12
42-444	Medical Devices	9
42-696/24-665	Special Topics: Wearable Health Technologies	12
16-868	Biomechanics & Motor Control	12
16-879	Medical Robotics	12
42-x00	BME Research* or 39-500 CIT Honors Research Project* or 42-6XX Clinical Course (Surgery for Engineers/Precision Medicine/ICU Medicine)	9-12

* The 42-x00 research project (42-200/300/400 Sophomore/Junior/Senior Biomedical Engineering Research Project OR 39-500 CIT Honors Research Project) must be on a BME topic that is aligned to the track, supervised or co-supervised by a BME faculty member, and conducted for 9 or more units of credit.

Some Special Topics and newly offered or intermittently offered courses may be acceptable as track electives. Students should consult with their BME advisors and petition the BME Undergraduate Affairs Committee for permission to include such courses as track electives. The course petition form can be found here (https://www.cmu.edu/bme/Academics/undergraduate-programs/advising.html#ug-course-petition).

Sample schedules can be found on the BME Additional Major (https://www.cmu.edu/bme/Academics/undergraduate-programs/major.html) page on the BME website.

Biomedical Devices (BMDV) Track

OVERVIEW

The BMDV track studies design, construction, and testing of devices at the interface of medicine and engineering. The topics include biomedical sensors, actuators, diagnostic devices, therapeutic devices, instruments, systems, and fundamental topics of device material, device fabrication, and device interaction with biological cells, tissues and organs. The Biomedical Device track will prepare students for leaders in the biomedical device industry and for further education in graduate/medical schools.

TARGETS

The BMDV track will prepare students to be leaders in the biomedical device industry and for further education in graduate/medical schools. It is ideal for students interested in combining the education of Biomedical Engineering with Electrical and Computer Engineering, or with Mechanical Engineering, or with Materials Science & Engineering.

REQUIREMENTS

In addition to the Biomedical Engineering core courses, students in the BMDV Track must take must take the following combination of **three** courses:

- One (1) **Required** BMDV Elective
- Two (2) BMDV Electives (either **Required** or **Additional**)

BMDV ELECTIVES

Required BMDV Electives (must take at least one of the following)

42-660	Bioinstrumentation	12
42-678	Medical Device Innovation and Realization	12
42-693/18-469	Special Topics in Integrated Systems Technology: Micro/Nano Biomedical Devices	12
42-694	Engineering Principles of Medical Devices	9

Additional BMDV Electives

42-433	Neural Technology: Sensing and Stimulation	12
42-444	Medical Devices	9
42-611/27-709	Biomaterials	12
42-616/27-514	Bio-nanotechnology: Principles and Applications	9
42-630	Introduction to Neural Engineering	12
42-641	Rehabilitation Engineering	9
42-648/	Cardiovascular Mechanics	12
42-650	Introduction to Biomedical Imaging	9
42-652/18-416	Nano-Bio-Photonics	12
42-675	Fundamentals of Computational Biomedical Engineering	12
42-696/24-665	Special Topics: Wearable Health Technologies	12
16-467	Introduction to Human Robot Interaction	12
16-879	Medical Robotics	12
42-6XX	Clinical Course (Surgery for Engineers/ Precision Medicine/ICU Medicine)	9
42-X00	BME Research* or 39-500 CIT Honors Thesis	9

* The 42-x00 research project (42-200/300/400 Sophomore/Junior/Senior Biomedical Engineering Research Project OR 39-500 CIT Honors Research Project) must be on a BME topic that is aligned to the track, supervised or co-supervised by a BME faculty member, and conducted for 9 or more units of credit.

Some Special Topics and newly offered or intermittently offered courses may be acceptable as track electives. Students should consult with their BME advisors and petition the BME Undergraduate Affairs Committee for permission to include such courses as track electives. The course petition form can be found here (https://www.cmu.edu/bme/Academics/undergraduate-programs/advising.html#ug-course-petition).

Sample schedules can be found on the BME Additional Major (https://www.cmu.edu/bme/Academics/undergraduate-programs/major.html) page on the BME website.

Biomedical Signal and Image Processing (BSIP) Track

OVERVIEW

The BSIP track addresses biomedical phenomena based on the information embedded in sensor-detected signals, including digital images and nerve electrical pulses. Students in this track will gain an understanding of the technologies involved in acquiring signals and images, the mathematical principles underlying the processing and analysis of signals, and the applications of signal/image processing methods in basic research and medicine.

TARGETS

This track aligns most naturally with a combined education of Biomedical Engineering and Electrical & Computer Engineering, which lays a solid foundation in signal processing principles. This track prepares students for careers in medical imaging or smart prosthetics. It also interfaces with many clinical practices including radiology, neurology/neurosurgery, and pathology.

REQUIREMENTS

In addition to the Biomedical Engineering core courses, students in the BSIP Track must take the following combination of **three** courses:

- One (1) **Required** BSIP elective
- Two (2) BSIP Electives (either **Required** or **Additional**)

BSIP ELECTIVES

Required BSIP Electives (must take at least one of the following)

42-650	Introduction to Biomedical Imaging	9
42-668	"Fun"-damentals of MRI and Neuroimaging Analysis	9
42-631	Neural Data Analysis	12
42-632	Neural Signal Processing	12

Additional BSIP Electives

42-437	Biomedical Optical Imaging	9
42-640/24-658	Image-Based Computational Modeling and Analysis	12
42-656	Introduction to Machine Learning for Biomedical Engineers	9
42-660	Bioinstrumentation	12
42-675	Fundamentals of Computational Biomedical Engineering	12
16-725	(Bio)Medical Image Analysis	12

18-491	Digital Signal Processing [1]	12
42-x00	BME Research* or 39-500 CIT Honors Research Project* or 42-6XX Clinical Course (Surgery for Engineers/Precision Medicine/ICU Medicine)	9-12

[1] Students make take either 18-491 Fundamentals of Signal Processing OR 18-792 Advanced Digital Signal Processing (but not both)

* The 42-x00 research project (42-200/300/400 Sophomore/Junior/Senior Biomedical Engineering Research Project OR 39-500 CIT Honors Research Project) must be on a BME topic that is aligned to the track, supervised or co-supervised by a BME faculty member, and conducted for 9 or more units of credit.

Some Special Topics and newly offered or intermittently offered courses may be acceptable as track electives. Students should consult with their BME advisors and petition the BME Undergraduate Affairs Committee for permission to include such courses as track electives. The course petition form can be found here (https://www.cmu.edu/bme/Academics/undergraduate-programs/advising.html#ug-course-petition).

Sample schedules can be found on the BME Additional Major (https://www.cmu.edu/bme/Academics/undergraduate-programs/major.html) page on the BME website.

Neuroengineering (Neuro) Track

OVERVIEW

The Neuroengineering (Neuro) track uses engineering techniques to examine, understand, and apply the properties of complex neural systems. Areas of interest include the research and development of neuroengineering technologies for sensing, interfacing, imaging, and modulating the nervous systems. Examples of applications include brain-computer interfaces for use in paralysis, neural stimulation device design for sensory and motor prostheses and basic science research, and neural recording and imaging devices.

TARGETS

This track aligns most naturally with a combined education of Biomedical Engineering and Electrical & Computer Engineering, which lays a solid foundation in signal processing principles. This track prepares students for careers in brain-computer interfaces, neural stimulators, and neuroprosthetics.

REQUIREMENTS

In addition to the Biomedical Engineering core courses, students in the BMEC Track must take must take the following combination of **three** courses:

- One (1) **Required** Neuro Elective
- Two (2) Neuro Electives (either **Required** or **Additional**)

NEURO ELECTIVES

Required Neuro Electives (must take at least one of the following)

42-630	Introduction to Neural Engineering	12
42-631	Neural Data Analysis	12
42-632	Neural Signal Processing	12

Additional Neuro Electives

42-433	Neural Technology: Sensing and Stimulation	12
42-437	Biomedical Optical Imaging	9
42-641	Rehabilitation Engineering	9
42-650	Introduction to Biomedical Imaging	9
42-652/18-416	Nano-Bio-Photonics	12
42-656	Introduction to Machine Learning for Biomedical Engineers	9
42-660	Bioinstrumentation	12
42-783	Neural Engineering Laboratory	12
15-386	Neural Computation	9
18-370	Fundamentals of Control	12
18-460	Optimization	12
42-x00	BME Research* or 39-500 CIT Honors Research Project* or 42-6XX Clinical Course (Surgery for Engineers/Precision Medicine/ICU Medicine)	9-12

* The 42-x00 research project (42-200/300/400 Sophomore/Junior/Senior Biomedical Engineering Research Project OR 39-500 CIT Honors Research Project) must be on a BME topic that is aligned to the track, supervised or co-supervised by a BME faculty member, and conducted for 9 or more units of credit.

Some Special Topics and newly offered or intermittently offered courses may be acceptable as track electives. Students should consult with their BME advisors and petition the BME Undergraduate Affairs Committee for permission to include such courses as track electives. The course petition form can be found here (https://www.cmu.edu/bme/Academics/undergraduate-programs/advising.html#ug-course-petition).

Sample schedules can be found on the BME Additional Major (https://www.cmu.edu/bme/Academics/undergraduate-programs/major.html) page on the BME website.

Tissue and Cell Biotherapeutics (TCB) Track

Note: This track combines the Biomaterials and Tissue Engineering (BMTE) and Cellular and Molecular Biotechnology (CMBT) tracks together. Students entered CMU prior to Fall 2024 may switch to this track.

OVERVIEW

The TCB track addresses issues at the interface of materials science, biology and engineering. The topics include the interactions between materials and cells or tissues, the effects of such interactions on cells and tissues, the design of materials for biological applications, and the engineering of new tissues. It emphasizes fundamentals and applications of biochemistry, biophysics, cell biology, material science, and processes on the nanometer to centimeter size scale. Students in this track acquire an understanding of the molecular and cellular bases of life processes and build skills in quantitative modeling of biological mass transport, drug delivery, and live cell-based biotechnologies and in technologies that exploit the unique properties of biomolecules and materials in non-biological settings.

TARGETS

The TCB track is ideal for students interested in combining the education of Biomedical Engineering with Materials Science & Engineering or with Chemical Engineering. The track may also interest students in Mechanical Engineering and Environmental Engineering who have an interest in molecular aspects of Biomedical Engineering. It provides the necessary foundation in chemistry, molecular processing, and/or materials science. Students of this track may develop careers in biotechnology, tissue engineering, biopharmaceuticals, biosensors, drug delivery, and biological aspects of environmental engineering.

REQUIREMENTS

In addition to the Biomedical Engineering core courses, students in the TCB Track must take the following combination of **three** courses:

- One (1) **Required** TCB elective
- Two (2) TCB Electives (either **Required** or **Additional**)

TCB ELECTIVES

Required TCB Electives (must take one of the following)

42-611/27-709	Biomaterials	12
42-612/27-520	Tissue Engineering	12
42-615	Biomaterial Host Interactions in Regenerative Medicine	12
42-620	Engineering Molecular Cell Biology	12
42-624	Biological Transport and Drug Delivery	9

Additional TCB Electives

42-613/27-570	Polymeric Biomaterials	12
42-616/27-514	Bio-nanotechnology: Principles and Applications	9
42-626/06-634	Drug Delivery Systems	9
42-645/24-655	Cellular Biomechanics	9
42-667	Biofabrication and Bioprinting	12
42-695	Special Topics: Engineering Protein Therapeutics	12
42/06-722	Bioprocess Design	12
03-320	Cell Biology	9

06-685	Bioseparations and Bioprocess Analytical Technologies	12
42-x00	BME Research* or 39-500 CIT Honors Research Project* or 42-6XX Clinical Course (Surgery for Engineers/Precision Medicine/ICU Medicine)	9-12

* The 42-x00 research project (42-200/300/400 Sophomore/Junior/Senior Biomedical Engineering Research Project OR 39-500 CIT Honors Research Project) must be on a BME topic that is aligned to the track, supervised or co-supervised by a BME faculty member, and conducted for 9 or more units of credit.

Some Special Topics and newly offered or intermittently offered courses may be acceptable as track electives. Students should consult with their BME advisors and petition the BME Undergraduate Affairs Committee for permission to include such courses as track electives. The course petition form can be found here (https://www.cmu.edu/bme/Academics/undergraduate-programs/advising.html#ug-course-petition).

Biomaterials and Tissue Engineering (BMTE) Track

Note: This track is not offered to Classes of 2027+

OVERVIEW

The BMTE track addresses issues at the interface of materials science, biology and engineering. The topics include the interactions between materials and cells or tissues, the effects of such interactions on cells and tissues, the design of materials for biological applications, and the engineering of new tissues.

TARGETS

The BMTE track is ideal for students interested in combining the education of Biomedical Engineering with Materials Science & Engineering or with Chemical Engineering. Both provide the necessary foundation in chemistry and/or materials science. Students of this track may develop careers in biotechnology, tissue engineering, biopharmaceuticals, and medical devices that leverage materials properties.

REQUIREMENTS

In addition to the Biomedical Engineering core courses, students in the BMTE Track must take the following combination of **three** courses:

- One (1) **Required** BMTE elective
- Two (2) BMTE Electives (either **Required** or **Additional**)

BMTE ELECTIVES

Required BMTE Electives (must take one of the following)

42-611/27-709	Biomaterials	12
42-612/27-520	Tissue Engineering	12
42-615	Biomaterial Host Interactions in Regenerative Medicine	12
42-667	Biofabrication and Bioprinting	12

Additional BMTE Electives

42-613/27-570	Polymeric Biomaterials	12
42-616/27-514	Bio-nanotechnology: Principles and Applications	9
42-620	Engineering Molecular Cell Biology	12
42-624	Biological Transport and Drug Delivery	9
03-320	Cell Biology	9
42-x00	BME Research* or 39-500 CIT Honors Research Project* or 42-6XX Clinical Course (Surgery for Engineers/Precision Medicine/ICU Medicine)	9-12

* The 42-x00 research project (42-200/300/400 Sophomore/Junior/Senior Biomedical Engineering Research Project OR 39-500 CIT Honors Research Project) must be on a BME topic that is aligned to the track, supervised or co-supervised by a BME faculty member, and conducted for 9 or more units of credit.

Some Special Topics and newly offered or intermittently offered courses may be acceptable as track electives. Students should consult with their BME advisors and petition the BME Undergraduate Affairs Committee for permission to include such courses as track electives. The course petition form can be found here (https://www.cmu.edu/bme/Academics/undergraduate-programs/advising.html#ug-course-petition).

Sample schedules can be found on the BME Additional Major (https://www.cmu.edu/bme/Academics/undergraduate-programs/major.html) page on the BME website.

Cellular and Molecular Biotechnology (CMBT) Track

Note: This track is not offered to Classes of 2027+

OVERVIEW

The CMBT track emphasizes fundamentals and applications of biochemistry, biophysics, and cell biology, and processes on the nanometer to micrometer size scale. Students in this track acquire understanding of the molecular and cellular bases of life processes, and build skills in quantitative modeling of biological mass transport, drug delivery, and live cell-based biotechnologies and in technologies that exploit the unique properties of biomolecules in non-biological settings.

TARGETS

The CMBT track is ideally suited for the combined education of Biomedical Engineering and Chemical Engineering, which provides a strong core of chemistry and molecular processing principles. The track may also interest students of Mechanical Engineering, Materials Science & Engineering, or Civil & Environmental Engineering who have an interest in molecular aspects of Biomedical Engineering. The CMBT track prepares students for careers in bio/pharmaceutical, medical diagnostics, biosensors, drug delivery, and biological aspects of environmental engineering.

REQUIREMENTS

In addition to the Biomedical Engineering core courses, students in the CMBT Track must take the following combination of **three** courses:

- One (1) **Required** CMBT Elective
- Two (2) CMBT Electives (either **Required** or **Additional**)

CMBT ELECTIVES

Required CMBT Electives (must take at least one of the following)

42-620	Engineering Molecular Cell Biology	12
42-621	Principles of Immunoengineering and Development of Immunotherapy Drugs	9
42-624	Biological Transport and Drug Delivery	9

Additional CMBT Electives

42-616/27-514	Bio-nanotechnology: Principles and Applications	9
42-626/06-634	Drug Delivery Systems	9
42-645/24-655	Cellular Biomechanics	9
42/06-722	Bioprocess Design	12
03-320	Cell Biology	9
42-x00	BME Research* or 39-500 CIT Honors Research Project* or 42-6XX Clinical Course (Surgery for Engineers/Precision Medicine/ICU Medicine)	9-12

* The 42-x00 research project (42-200/300/400 Sophomore/Junior/Senior Biomedical Engineering Research Project OR 39-500 CIT Honors Research Project) must be on a BME topic that is aligned to the track, supervised or co-supervised by a BME faculty member, and conducted for 9 or more units of credit.

Some Special Topics and newly offered or intermittently offered courses may be acceptable as track electives. Students should consult with their BME advisors and petition the BME Undergraduate Affairs Committee for permission to include such courses as track electives. The course petition form can be found here (https://www.cmu.edu/bme/Academics/undergraduate-programs/advising.html#ug-course-petition).

Sample schedules can be found on the BME Additional Major (https://www.cmu.edu/bme/Academics/undergraduate-programs/major.html) page on the BME website.

Self-Designed Biomedical Engineering (SBME) Track

The SBME track is aimed at helping highly motivated students who have a strong sense of career direction that falls beyond the scope of regular Biomedical Engineering tracks. Students are allowed to design the "track"

portion of the curriculum in consultation with the faculty. Example themes include medical robotics, embedded medical systems, or computational biomedical engineering.

REQUIREMENTS

In addition to the Biomedical Engineering core requirements, students must take **three** elective courses of at least 9 units each. These elective courses must form a coherent theme that is relevant to biomedical engineering. In addition, at least one of the elective courses must be judged by the Biomedical Engineering Undergraduate Affairs Committee to have substantial biological or medical content.

If undergraduate research is part of the SBME track, the research project must be on a BME topic that is aligned to the track, supervised or co-supervised by a BME faculty member, and conducted for 9 or more units of credit.

PETITION PROCEDURE

1. Students wishing to pursue a self-designed track should first consult with Kristin Kropf (https://engineering.cmu.edu/directory/bios/kropf-kristin.html) (Undergraduate Program and Alumni Relations Coordinator).
2. A SBME track proposal must be submitted electronically to Kristin Kropf (https://engineering.cmu.edu/directory/bios/kropf-kristin.html) at least three weeks prior to Pre-Registration during the spring of the sophomore year. The proposal must include:
   - The three courses of the designed track, including catalog descriptions and when these courses are expected to be taken.
   - A justification of how these courses form a coherent theme relevant to biomedical engineering and why the regular tracks do not relate to the proposed theme
   - Two alternative courses that may substitute for one of the proposed courses, in case the original course is not available.
3. Once approved by the Biomedical Engineering Undergraduate Affairs Committee, the student must sign an agreement listing the theme and the three courses comprising the SBME track.
4. In the event that issues beyond the student's control, such as course scheduling or cancellation, prevent the student from completing the approved course plan, the student may petition the Biomedical Engineering Undergraduate Affairs Committee to
5. Substitute a course with another course that fits the approved theme, OR
6. Complete one of the regular tracks (all classes)

Full-Time Faculty

ABBOTT, ROSALYN, Associate Professor of Biomedical Engineering – Ph.D., University of Vermont, 2011;

BARATI FARIMANI, AMIR, Assistant Professor, Mechanical Engineering and Biomedical Engineering – Ph.D., University of Illinois at Urbana-Champaign, 2015;

BARTH, ALISON L., Professor, Biological Sciences, and Biomedical Engineering – Ph.D., University of California, Berkeley, 1997;

BETTINGER, CHRISTOPHER J. , Professor of Biomedical Engineering and Materials Science & Engineering – Ph.D., Massachusetts Institute of Technology, 2008;

CAMPBELL, PHIL G. , Research Professor, Biomedical Engineering, Engineering Research Accelerator, Biological Sciences, and Materials Science & Engineering – Ph.D., The Pennsylvania State University, 1985;

CHALACHEVA, P. SANG, Assistant Teaching Professor of Biomedical Engineering – Ph.D., University of Southern California, 2014;

CHAMANZAR, MAYSAM , Dr. William D. and Nancy W. Strecker Career Development Associate Professor, Electrical and Computer Engineering, Biomedical Engineering – Ph.D., Georgia Institute of Technology, 2012;

CHASE, STEVEN M., Professor of Biomedical Engineering and Center for the Neural Basis of Cognition – Ph.D., Johns Hopkins University, 2006;

CHOSET, HOWIE, Professor, Robotics Institute, Biomedical Engineering, and Electrical & Computer Engineering – Ph.D., California Institute of Technology , 1996;

COHEN-KARNI, TZAHI (ITZHAQ), Professor of Biomedical Engineering and Materials Science & Engineering – Ph.D., Harvard University, 2011;

COOK, KEITH E., David Edward Schramm Professor and Department Head, Biomedical Engineering – Ph.D., Northwestern University, 2000;

DANDIN, MARC, Assistant Professor, Electrical & Computer Engineering and Biomedical Engineering – Ph.D., University of Maryland, 2012;

DOMACH, MICHAEL M., Professor, Chemical Engineering and Biomedical Engineering – Ph.D., Cornell University, 1983;

ERICKSON, ZACKORY, Assistant Professor, Robotics Institute and Biomedical Engineering – Ph.D., Georgia Institute of Technology, 2021;

FEDDER, GARY K., Howard M. Wilkoff Professor, Institute for Complex Engineering Systems, Biomedical Engineering, Electrical & Computer Engineering, Robotics Institute – Ph.D., University of California, Berkeley, 1994;

FEINBERG, ADAM W., Arthur Hamerschlag Career Development Professor; Professor of Biomedical Engineering and Materials Science & Engineering – Ph.D., University of Florida, 2004;

GALEOTTI, JOHN, Senior Systems Scientist, Robotics Institute and Associate Professor of Biomedical Engineering – Ph.D, Carnegie Mellon University, 2007;

GEYER, HARMUT, Associate Professor, Robotics Institute and Biomedical Engineering – Ph.D., Friedrich-Schiller-University of Jena, Germany, 2005 ;

GITTIS, ARYN, Associate Professor, Biological Sciences, and Biomedical Engineering – Ph.D., University of California, San Diego, 2008;

GRANDE GUTIÉRREZ, NOELIA, Assistant Professor, Mechanical and Biomedical Engineering – PhD, Stanford, 2019;

GROVER, PULKIT, Angel Jordan Associate Professor, Electrical & Computer Engineering, Center for Neural Basis of Cognition, and Biomedical Engineering – Ph.D., University of California, Berkeley, 2010;

HALILAJ, ENI, Assistant Professor, Mechanical Engineering and Biomedical Engineering – Ph.D., Brown University, 2015;

HAMMAL, ZAKIA, Systems Faculty, Robotics Institute; Assistant Research Professor, Biomedical Engineering – Ph.D.,

HE, BIN, Trustee Professor of Biomedical Engineering, Electrical & Computer Engineering, Neuroscience Institute – Ph.D., Tokyo Institute of Technology, 1988;

JUST, MARCEL, D.O. Hebb University Professor of Psychology and Biomedical Engineering Director, Center for Cognitive Brain Imaging – Ph.D., Stanford University, 1972;

KAINERSTORFER, JANA M., Professor and Associate Department Head for Faculty and Graduate Affairs, Biomedical Engineering – Ph.D., University of Vienna, 2010;

KASS, ROBERT, Maurice Falk Professor, Statistics, Department of Machine Learning, Center for the Neural Basis of Cognition, and Biomedical Engineering Interim co-Director, Center for the Neural Basis of Cognition – Ph.D., University of Chicago, 1980;

KELLY, SHAWN, Adjunct Associate Professor of Biomedical Engineering – Ph.D., Massachusetts Institute of Technology, 2003;

KUHLMAN, SANDRA, Associate Professor, Biological Sciences, and Biomedical Engineering – Ph.D., University of Kentucky, 2001;

LEDUC, PHILIP R., William J. Brown Professor of Mechanical Engineering, Biomedical Engineering, and Biological Sciences – Ph.D., Johns Hopkins University, 1999;

LEE, TAI SING, Professor, Computer Science, Center for the Neural Basis of Cognition and Biomedical Engineering – Ph.D., Harvard University, 1993;

MAJIDI, CARMEL, Associate Professor of Mechanical Engineering and Biomedical Engineering – Ph.D., University of California, Berkeley, 2007;

MOORE, AXEL, Assistant Professor, Biomedical Engineering – Ph.D., University of Delaware, 2017;

NIEPA, TAGBO H.R., Associate Professor, Biomedical Engineering and Chemical Engineering – Ph.D., Syracuse University, 2014;

OLSON, CARL, Professor, Center for the Neural Basis of Cognition and Biomedical Engineering – Ph.D., University of California, Berkeley, 1979;

OZDOGANLAR, BURAK , Ver Planck Professor, Mechanical Engineering and Biomedical Engineering – Ph.D., University of Michigan, 1999;

PALCHESKO, RACHELLE, Assistant Teaching Professor of Biomedical Engineering – Ph.D., Duquesne University, 2011;

PANAT, RAHUL, Russell V. Trader Associate Professor, Mechanical Engineering, Civil & Environmental Engineering, Materials Science & Engineering, and Biomedical Engineering – Ph.D., University of Illinois at Urbana-Champaign, 2004;

REN, XI (CHARLIE), Associate Professor of Biomedical Engineering – Ph.D., Peking University, 2011;

RIVIERE, CAMERON N., Associate Research Professor, Robotics Institute and Biomedical Engineering – Ph.D., Johns Hopkins University, 1995;

SCHNEIDER, JAMES W., Professor of Chemical Engineering and Biomedical Engineering – Ph.D., University of Minnesota, 1998;

SHIMADA, KENJI, Theodore Ahrens Professor, Mechanical Engineering and Biomedical Engineering – Ph.D., Massachusetts Institute of Technology, 1993;

SHINN-CUNNINGHAM, BARBARA, Director, Carnegie Mellon Neuroscience Institute Professor, Center for the Neural Basis of Cognition, Biomedical Engineering, Psychology, and Electrical & Computer Engineering – Ph.D., Massachusetts Institute of Technology, 1994;

SMITH, MATTHEW, Professor, Biomedical Engineering and Center for the Neural Basis of Cognition – Ph.D., New York University, 2003;

SYDLIK, STEFANIE, Professor of Chemistry and Biomedical Engineering – Ph.D., Massachusetts Institute of Technology, 2012;

SZAFRON, JASON, Assistant Professor, Biomedical Engineering – Ph.D., Yale University, 2020;

TAYLOR, REBECCA, Ph.D. – Associate Professor of Mechanical Engineering and Biomedical Engineering, Stanford University, 2013;

TILTON, ROBERT D. , Chevron Professor; Professor, Biomedical Engineering and Chemical Engineering – Ph.D., Stanford University, 1991;

TRUMBLE, DENNIS, Emeritus Research Professor, Biomedical Engineering and Center for the Neural Basis of Cognition – Ph.D., Carnegie Mellon University, 2010;

TUCKER, CONRAD, Director of CMU-Africa and Associate Dean for International Affairs-Africa, Professor of Mechanical Engineering, Biomedical Engineering, Machine Learning, and the Robotics Institute – PhD, MBA, University of Illinois, Urbana-Champaign, 2011;

VERSTYNEN, TIMOTHY, Associate Professor, Psychology, Center for the Neural Basis of Cognition and Biomedical Engineering – Ph.D., University of California, Berkeley, 2006;

WANG, YU-LI, Mehrabian Professor of Biomedical Engineering – Ph.D., Harvard University, 1980;

WASHBURN, NEWELL R. , Associate Professor of Biomedical Engineering, Chemistry, and Materials Science & Engineering – Ph.D., University of California, Berkeley, 1998;

WEBER, DOUGLAS J, Akhtar and Bhutta Professor, Mechanical Engineering, Neuroscience Institute and Biomedical Engineering – Ph.D., Arizona State University, 2001;

WEBSTER-WOOD, VICTORIA , Assistant Professor, Mechanical Engineering and Biomedical Engineering – Ph.D., Case Western Reserve University, 2017;

WHITEHEAD, KATHRYN A, Professor of Chemical and Biomedical Engineering – Ph.D., University of California, Santa Barbara, 2007;

WOOD, SOSSENA, Assistant Professor of Biomedical Engineering – Ph.D., University of Pittsburgh, 2018;

YTTRI, ERIC, Assistant Professor, Biological Sciences, Center for the Nneural Basis of Cognition, Biomedical Engineering – Ph.D., Washington University in St Louis, 2011;

YU, BYRON, Gerard G. Elia Career Development Professor of Biomedical Engineering and Electrical & Computer Engineering – Ph.D., Stanford University, 2007;

YU, KAI, Research Scientist of Biomedical Engineering – Ph.D., University of Minnesota, Minneapolis, 2018;

ZAPANTA, CONRAD M., Associate Dean of Undergraduate Studies, College of Engineering and Teaching Professor, Biomedical Engineering, – Ph.D., The Pennsylvania State University, 1997;

ZHANG, YONGJIE JESSICA, George Tallman Ladd and Florence Barrett Ladd Professor, Mechanical Engineering and Biomedical Engineering – Ph.D., University of Texas at Austin, 2005;

ZHAO, YONGXIN (LEO), Associate Professor, Biomedical Engineering and Biological Sciences – Ph.D., University of Alberta, 2014;

ZHENG, SIYANG, Professor, Biomedical Engineering and Electrical and Computer Engineering – Ph.D., California Institute of Technology, 2007;