CURRICULUM

CORE COURSES (84 UNITS)

42 Units Artificial Intelligence Core

- Systems and Tool Chains for AI Engineering (12 units)

  Principles and key trade-offs in data collection and storage, data engineering, neural network engineering, framework architectures, and managing constraints

- Introduction to Machine Learning for Engineers (12 units)

  Introduction to machine learning with a special focus on engineering applications covers probability and Bayesian learning, generative and discriminative classification methods, supervised and unsupervised learning, neural networks, support vector machines, clustering, dimensionality reduction, regression, optimization, evolutionary computation and search.

- Introduction to Deep Learning for Engineers (6 units)

  The basics of deep neural networks and their applications to different tasks in engineering. Convolutional neural networks (CNN), recurrent neural networks (RNN), long short term memory (LSTM), generative adversarial networks (GAN), variational autoencoders (VAE), graph neural networks (GNN), attention mechanism and transfer learning.

- Trustworthy and Ethical AI Engineering (12 units)

  Understanding of different kinds of threats and concerns for deploying AI solutions in the real world, an exposure to end-to-end deployment challenges, societal issues, and policy challenges in realizing these; and an exposure to best practices for avoiding these concerns.

12 Units AI Applications in BME

Hands-on experience in applying the fundamentals of AI/ML to problems in a variety of biomedical applications. Students will work in teams to design, develop, and evaluate an AI/ML system.

30 Units BME Core Electives

Choose one of the five BME cores:

- Biomaterials and Tissue Engineering
- Biomechanics
- Biomedical Imaging and Bioinformatics
- Neural Engineering
- Physiology and Cellular/Molecular Biology

PHYSIOLOGY (12 UNITS)

Choose one:

- 42-702 Advanced Physiology
- 03-763 Advanced Systems Neuroscience

May be waived if the student has previously taken a CMU-equivalent course in physiology. If waived, the student would instead take 12 additional free elective units of BME.

RESTRICTED ELECTIVE (12 UNITS)

12 Units of approved coursework in the BME graduate curriculum

ADDITIONAL REQUIREMENTS

Biomedical Engineering Seminar Attend seminar each semester the student is enrolled in the program: 42-701 (0 units) *or* 42-801 (3 units).

A minimum of 48 units from BME (42-XXX)

Total Units 108 units

BME CORE ELECTIVES

Students must take **at least 30 units** of the chosen courses within **one** of the BME cores. See sample course plans in the next section.

Biomaterials and Tissue Engineering		
Number	**Name**	**Units**
42-610	Intro to Biomaterials	9
42-611	Engineering Biomaterials	12
42-620	Engineering Molecular Cell Biology	12
42-612	Tissue Engineering	12
42-613	Molecular and Micro-Scale Polymeric Biomaterials in Medicine	9
42-670	Biomaterial Host Interactions in Regenerative Medicine	12
42-673	Special Topics: Stem Cell Engineering	9
42-676	Bio-nanotechnology: Principles and Applications	9
42-693	Special Topics in Integrated Systems Technology: Micro/Nano Biomedical Devices	12
02-730	Cell and Systems Modeling	12
09-707	Nanoparticles	12

Biomechanics		
Number	**Name**	**Units**
42-691	Biomechanics of Human Movement	12
42-640	Image-Based Computational Modeling and Analysis	12
42-645	Cellular Biomechanics	9
42-648	Cardiovascular Mechanics	12
42-649	Introduction to Biomechanics	12
42-677	Rehabilitation Engineering	9
06-610	Rheology and Structure of Complex Fluids	9
16-868	Biomechanics and Motor Control	12

Biomedical Imaging and Bioinformatics		
Number	**Name**	**Units**
42-631	Neural Data Analysis	12
42-632	Neural signal processing	12
42-640	Image-Based Computational Modeling and Analysis	12
42-737	Biomedical Optical Imaging	12
42-689	Introduction to Bioimaging	9
42-668	"Fun"-damentals of MRI and Neuroimaging Analysis	9
02-730	Cell and Systems Modeling	12
03-534	Biological Imaging and Fluorescence Spectroscopy	9
03-712	Computational Methods for Biological Modeling and Simulation	12
16-725	(Bio) Medical Image Analysis	12
86-675	Computational Perception	12
PittBIOE 2330	Biomedical Imaging	9

Neural Engineering		
Number	**Name**	**Units**
42-630	Intro to Neural Engineering	12
42-631	Neural Data Analysis	12
42-632	Neural Signal Processing	12
42-783	Neural Engineering Laboratory	12
03-763	Advanced Systems Neuroscience	12
03-762	Advanced Cellular Neuroscience	12
86-765	Cognitive Neuroscience	12
18-491	Fundamentals of Signal Processing	12
18-792	Advanced Digital Signal Processing	12
18-794	Pattern Recognition Theory	12
86-675	Computational Perception	12
36-759	Statistical Models of the Brain	12

Physiology and Cellular/Molecular Biology		
Number	**Name**	**Units**
42-702	Advanced Physiology	12
42-620	Engineering Molecular Cell Biology	12
42-673	Special Topics: Stem Cell Engineering	9
42-684	Principles of Immunoengineering and Development of Immunotherapy Drugs	9
03-741	Advanced Cell Biology	12
03-742	Advanced Molecular Biology	12
03-751	Advanced Developmental Biology and Human Health	9
03-762	Advanced Cellular Neuroscience	12

SAMPLE COURSE PLANS

BME core electives, restricted elective.
Minimum number of BME (42-XXX) units: 48

Biomaterials and Tissue Engineering

First Year

	Fall	Units		Spring	Units
14-813	Systems and Tool Chains for AI Engineering	12	TBD	Introduction to Deep Learning for Engineers	6
18-661 or 24-787	Introduction to Machine Learning for Engineers	12	TBD	Trustworthy and Ethical AI Engineering	12
42-702	Advanced Physiology	12	42-TBD	AI Applications in BME	12
42-701	Biomedical Engineering Seminar	0	02-730	Cell and Systems Modeling	12
	Total:	**36**	42-701	Biomedical Engineering Seminar	0
				Total:	**42**

Second Year

	Fall	Units
42-612	Tissue Engineering	12
42-620	Engineering Molecular Cell Biology	12
42-693	Special Topics in Integrated Systems Technology: Micro/Nano Biomedical Devices	12
42-701	Biomedical Engineering Seminar	0
	Total:	**36**

Biomechanics

First Year

	Fall	Units		Spring	Units
14-813	Systems and Tool Chains for AI Engineering	12	TBD	Introduction to Deep Learning for Engineers	6
18-661 or 24-787	Introduction to Machine Learning for Engineers	12	TBD	Trustworthy and Ethical AI Engineering	12
42-702	Advanced Physiology	12	42-TBD	AI Applications in BME	12
42-701	Biomedical Engineering Seminar	0	42-645	Cellular Biomechanics	9
	Total:	**36**	42-701	Biomedical Engineering Seminar	0
				Total:	**39**

Second Year

	Fall	Units
42-640	Image-Based Computational Modeling and Analysis	12
42-691	Biomechanics of Human Movements	12
16-879	Medical Robotics	12
42-701	Biomedical Engineering Seminar	0
	Total:	**36**

Biomedical Imaging and Bioinformatics

First Year

	Fall	Units		Spring	Units
14-813	Systems and Tool Chains for AI Engineering	12	TBD	Introduction to Deep Learning for Engineers	6
18-661 or 24-787	Introduction to Machine Learning for Engineers	12	TBD	Trustworthy and Ethical AI Engineering	12
42-702	Advanced Physiology	12	42-TBD	AI Applications in BME	12
42-701	Biomedical Engineering Seminar	0	42-737	Biomedical Optical Imaging	12
	Total:	**36**	42-701	Biomedical Engineering Seminar	0
				Total:	**42**

Second Year

	Fall	Units
42-640	Image-Based Computational Modeling and Analysis	12
42-631	Neural Data Analysis	12
18-794	Pattern Recognition Theory	12
42-701	Biomedical Engineering Seminar	0
	Total:	**36**

Neural Engineering

First Year

	Fall	Units		Spring	Units
14-813	Systems and Tool Chains for AI Engineering	12	TBD	Introduction to Deep Learning for Engineers	6
18-661 or 24-787	Introduction to Machine Learning for Engineers	12	TBD	Trustworthy and Ethical AI Engineering	12
42-702	Advanced Physiology	12	42-TBD	AI Applications in BME	12
42-701	Biomedical Engineering Seminar	0	42-630	Introduction to Neural Engineering	12
	Total:	**36**	42-701	Biomedical Engineering Seminar	0
				Total:	**42**

Second Year

	Fall	Units
42-631	Neural Data Analysis	12
42-783	Neural Engineering Laboratory	12
16-824	Visual Learning and Recognition	12
42-701	Biomedical Engineering Seminar	0
	Total:	**36**

Physiology and Cellular/Molecular Biology

First Year

	Fall	Units		Spring	Units
14-813	Systems and Tool Chains for AI Engineering	12	TBD	Introduction to Deep Learning for Engineers	6
18-661 or 24-787	Introduction to Machine Learning for Engineers	12	TBD	Trustworthy and Ethical AI Engineering	12
42-702	Advanced Physiology	12	42-TBD	AI Applications in BME	12
42-701	Biomedical Engineering Seminar	0	42-673	Special Topics: Stem Cell Engineering	9
	Total:	**36**	42-701	Biomedical Engineering Seminar	0
				Total:	**39**

Second Year

	Fall	Units
42-620	Engineering Molecular Cell Biology	12
03-751	Advanced Developmental Biology and Human Health	12
42-611	Engineering Biomaterials	12
42-701	Biomedical Engineering Seminar	0
	Total:	**36**