

SYSTEMS SCIENCE AND ENGINEERING, BSE

Systems Engineers provide technical management for societal-scale problems that often encompass the connections between the physical and the information world. Examples of the many cutting-edge applications include autonomous robotics, smart buildings, national power grid management, global networks, service optimization, and biological systems. Systems engineering is the set of reusable mathematics, intellectual tools, and methodologies for attacking large-scale engineering problems. These common tools are adaptable for problems in different engineering domains (e.g., electrical, mechanical, biological, chemical, and computing) and help us understand, design, and manage systems that contain elements from multiple domains. Systems engineering deals with how we extract useful, abstract models from lower level systems, use these models to analyze and predict behavior, and use the analysis to control behavior and optimize/synthesize solutions.

System engineering helps us understand what happens when we compose many elements, each with their own behavior, and how to design and constrain the individual elements to engineer desired behavior for the composed system.

For more information: <https://www.seas.upenn.edu/prospective-students/undergrad/majors/systems-science-and-engineering/>

Systems Science and Engineering (SSE) Major Requirements

37 course units are required.

Code	Title	Course Units
Engineering		
<i>Systems Foundations</i>		
CIS 1100	Introduction to Computer Programming (or equivalent)	1
	or ENGR 1050 Introduction to Scientific Computing	
ESE 1110	Atoms, Bits, Circuits and Systems ¹	1
CIS 1200	Programming Languages and Techniques I	1
ESE 2040	Decision Models	1
ESE 2100	Introduction to Dynamic Systems	1
ESE 2240	Signal and Information Processing	1.5
ESE 3030	Stochastic Systems Analysis and Simulation	1
<i>Information Systems Electives</i>		
Select 3 from the following:		3
CIS 2400	Introduction to Computer Systems	
CIS 4500	Database and Information Systems	
ESE 2000	Artificial Intelligence Lab: Data, Systems, and Decisions	
ESE 3050	Foundations of Data Science	
ESE 3250	Fourier Analysis and Applications in Engineering, Mathematics, and the Sciences	
ESE 4070	Introduction to Networks and Protocols	
ESE 5000	Linear Systems Theory	

ESE 5050	Feedback Control Design and Analysis
ESE 5060	Introduction to Optimization Theory
ESE 5120	Dynamical Systems for Engineering and Biological Applications
ESE 5140	Graph Neural Networks
ESE 5280	Estimation and Detection Theory
ESE 5310	Digital Signal Processing
ESE 5450	Data Mining: Learning from Massive Datasets
ESE 5460	Principles of Deep Learning
ESE 6050	Modern Convex Optimization
ESE 6060	Combinatorial Optimization
ESE 6150	F1/10 Autonomous Racing Cars
ESE 6180	Learning for Dynamics and Control
ESE 6190	Model Predictive Control
ESE 6500	Learning in Robotics
ESE 6740	Information Theory
NETS 2120	Scalable and Cloud Computing
NETS 3120	Theory of Networks
NETS 4120	Algorithmic Game Theory

Systems Project

Select one of the following:		1
ESE 2900/2910	Introduction to Electrical and Systems Engineering Research Methodology	
ESE 3060	Deep Learning: A Hands-on Introduction	
ESE 3500	Embedded Systems/Microcontroller Laboratory	
ESE 3600	TinyML: Tiny Machine Learning for Embedded Systems	
ESE 4210	Control For Autonomous Robots	
ESE 5050	Feedback Control Design and Analysis ²	
BE 5700	Biomechanics ²	
BE 4700	Medical Devices ²	
ESE 4500	Senior Design Project I - EE and SSE	1
ESE 4510	Senior Design Project II - EE and SSE	1
Engineering Elective		1
Engineering Elective 200 Level or above		1
Math and Natural Science		
MATH 1400	Calculus, Part I	1
MATH 1410	Calculus, Part II	1
MATH 2400	Calculus, Part III	1
ESE 3010	Engineering Probability	1
ESE 4020	Statistics for Data Science	1
or ESE 5420	Statistics for Data Science	
PHYS 0140	Principles of Physics I (without laboratory)	1-1.5
or PHYS 0150	Principles of Physics I: Mechanics and Wave Motion	
or PHYS 0170	Honors Physics I: Mechanics and Wave Motion	
or MEAM 1100	Introduction to Mechanics	
ESE 1120	Engineering Electromagnetics	1.5
or PHYS 0141	Principles of Physics II (without laboratory)	
or PHYS 0151	Principles of Physics II: Electromagnetism and Radiation	
or PHYS 0171	Honors Physics II: Electromagnetism and Radiation	

CHEM 1012	General Chemistry I	1
or EAS 0091	Chemistry Advanced Placement/International Baccalaureate Credit (Engineering Students Only)	
or BIOL 1101	Introduction to Biology A	
or BIOL 1121	Introduction to Biology - The Molecular Biology of Life	
MATH 3120	Linear Algebra	1
or MATH 3130	Computational Linear Algebra	
or MATH 3140	Advanced Linear Algebra	
or MATH 3700	Algebra	
Natural Science Lab (if applicable) ³		.5
Professional Electives		
<i>Technology Management Electives</i>		
ESE 4000	Engineering Economics	1
or EAS 5450	Engineering Entrepreneurship I	
or EAS 5950	Foundations of Leadership	
or MGMT 2370	Management of Technology	
or OIDD 2360	Scaling Operations in Technology Ventures: Linking Strategy and Execution	
<i>Societal Problem Application</i>		
Select 3 Societal Problem Electives ⁴		3
General Electives ⁵		
EAS 2030	Engineering Ethics (or equivalent)	1
or LAWM 5060 ML: Technology Law		
Select 4 Social Science or Humanities courses		4
Select 2 Social Science or Humanities or Technology in Business & Society courses		2
Total Course Units		37

- Data Science and Artificial Intelligence
- Decision Science
- Robotics

The degree and major requirements displayed are intended as a guide for students entering in the Fall of 2023 and later. Students should consult with their academic program regarding final certifications and requirements for graduation.

¹ If not taken by the end of freshman year, must be replaced by another department approved Engineering course.

² If ESE 5050 or BE 5700 or ESE 3600 is taken, an additional .5 CU engineering credit is required.

³ This category requires 10 CU, including two .5 CU Natural Science Labs. Several of the courses above are 1.5 CU and already include .5 CU Natural Science Lab. If the courses selected do not total 10 CUs, you will be required to complete the additional CUs required with up to two .5 CU Natural Science Labs from the following list: BIOL 1124 Introductory Organismal Biology Lab, CHEM 1101 General Chemistry Laboratory I, MEAM 1470 Introduction to Mechanics Lab, PHYS 0050 Physics Laboratory I, PHYS 0051 Physics Laboratory II, or another department approved Natural Science Lab.

⁴ A complete list of approved SPA electives can be found on the ESE undergraduate programs webpage (<https://www.ease.upenn.edu/undergraduate-2/systems-science-and-engineering-major/sse-sample-curriculum/>)

⁵ Must include a Writing Seminar (a list of approved Writing Seminars can be found in the SEAS Undergraduate Handbook (<https://ugrad.seas.upenn.edu/student-handbook/courses-requirements/writing-courses/>))

Concentrations

Students may select one of three concentrations: