Interdisciplinary Programs

Carnegie Mellon University offers several degree programs and courses of study which are coordinated by multiple colleges, reflecting the interdisciplinary nature of the university. These are detailed below.

Intercollege Majors

- BXA Intercollege Degree Programs
  - Bachelor of Humanities and Arts Program
  - Bachelor of Engineering Studies and Arts Program
  - Bachelor of Science and Arts Program
  - Bachelor of Computer Science and Arts Program
- B.S. in Computational Finance
- B.S. in Music and Technology
- B.S. in Neuroscience
- B.S. in Psychology and Biological Sciences
- Major in General Studies

INTERCOLLEGE ADDITIONAL MAJOR

- Environmental & Sustainability Studies
- BXA Intercollege Degree Programs
  - Engineering and Arts

Intercollege Minors

- Minor in Computational Finance
- Minor in Environmental & Sustainability Studies
- Minor in Game Design (IDeATe)
- Minor in Health Care Policy and Management
- Minor in Immersive Technologies in Arts & Culture

BXA Intercollege Degree Programs

The BXA Intercollege Degree Programs enable students the freedom to individualize their educational experience by promoting integration, balance and innovation. BXA offers the following programs:

- Bachelor of Humanities and Arts
- Bachelor of Engineering Studies and Arts
- Bachelor of Computer Science and Arts
- Bachelor of Science and Arts
- Engineering and Arts Additional Major

For detailed information on the BXA Intercollege Degree Programs, go to BXA Intercollege Degree Programs (http://coursecatalog.web.cmu.edu/intercollegeprograms/bxaintercollege/).

Bachelor of Science in Computational Finance

The Mellon College of Science, the Heinz College of Public Policy and Management and the Tepper School of Business jointly offer a degree uniquely designed to meet the quantitative needs of the finance industry. Modeled after the highly successful Carnegie Mellon Master of Science in Computational Finance, this degree allows students to develop a deep knowledge of mathematics, probability, statistics, and the applications of these disciplines to finance. Students who complete this degree may directly enter the finance industry, enter other industries where applied mathematics training is appropriate, or pursue advanced degrees in economics, finance or the mathematical sciences. Students entering the work force upon completion of this degree may wish to later complement their undergraduate degree with a Master's degree in Business Administration or another professional degree. Students who might eventually pursue doctoral degrees in economics, finance, statistics or mathematics should seek advising on how to use their electives in order to prepare for graduate work in their chosen disciplines.

The Bachelor of Science in Computational Finance is an Intercollege Program. Students may pursue Computational Finance as their primary major with either the Mellon College of Science (MCS) or the Tepper School of Business (Tepper) as their home college. The coursework required for the major is essentially the same in each case, with a few minor exceptions outlined below. The general education requirements for the degree depend on the student's home college.

Students who pursue Computational Finance as an additional major will remain in the college of their primary major. Additional majors must complete the Major Requirements outlined below, but not the General Education Requirements outlined for MCS and Tepper students. Additional majors will complete the general education requirements for their home college.

Admission to the major in Computational Finance is by application. Applications are accepted each fall and spring semester. The application deadline has traditionally been just after the mid-semester break.

Applicants must have taken (or be currently taking) at the time of application: 21-127 Concepts of Mathematics (or 21-128), 21-241 Matrices and Linear Transformations (or 21-242), 21-270 Introduction to Mathematical Finance. Students from any college or program at Carnegie Mellon are welcome to apply to enroll in the major. Additional information about computational finance and the Undergraduate Computational Finance Program at Carnegie Mellon can be found on the BSCF Program website.

Several majors are prohibited in combination with the Computational Finance major (either as Primary/Additional majors or as Dual Degrees) due to excessive overlap with the Computational Finance curriculum. These include the Business Administration major, the major in Mathematical Sciences (including any of the various concentrations), and the major in Economics and Mathematical Sciences.

Major Requirements

The major in Computational Finance is built around a core sequence of courses in mathematical finance. This core is supported by courses providing foundational mathematical skills and augmented with coursework in the related areas of Statistics, Computer Science, and Economics. Additionally the major provides training in the "soft skills" required for work in a corporate environment. The major also requires the completion of several depth electives, allowing students to tailor their education to their particular interests and needs.

The major requirements are the same for additional majors as they are for majors whose home college is MCS. There are a few slight differences for students whose home college is Tepper. These differences are described in the sections for Depth Electives and Professional Development below.

Foundations

21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	12
21-241	Matrices and Linear Transformations	11
21-259	Calculus in Three Dimensions	10
21-260	Differential Equations	9
21-369	Numerical Methods	12
70-122	Introduction to Accounting	9

Mathematical Finance

21-270	Introduction to Mathematical Finance	9
21-370	Discrete Time Finance	9
21-420	Continuous-Time Finance	9
46-977	MSCF Studies in Financial Engineering	6

Statistics

21-325	Probability	9
36-226	Introduction to Statistical Inference	9
36-401	Modern Regression	9

Programming

15-110	Principles of Computing	10
15-112	Fundamentals of Programming and Computer Science	12
15-122	Principles of Imperative Computation	12

Economics

73-102	Principles of Microeconomics	9
or 73-104	Principles of Microeconomics Accelerated	

73-103	Principles of Macroeconomics	9
73-240	Intermediate Macroeconomics	9

Professional Development

94-700	Organizational Design & Implementation	6
95-717	Writing for Information Systems Management	6
95-718	Professional Speaking	6

Note: Majors in the Tepper School of Business take 70-311 Organizational Behavior as part of the Functional Business Core curriculum. This course will satisfy the 94-700 Organizational Design & Implementation requirement for these students. Majors in the Tepper School of Business also take 70-340 Business Communications as part of the Functional Business Core curriculum. This course will satisfy the 95-717 Writing for Information Systems Management requirement for these students.

Depth Electives

Depth electives give students an opportunity to tailor their coursework to their particular interests. Students completing the major will take three depth electives (the minimum requirement is 24 units - the equivalent of two 9 unit courses and one 6 unit course).

Note: Tepper students are required to select 70-391 Finance as one of their depth electives.

Depth electives are intended to develop a student's background in an area that is applicable to the finance industry. Courses in finance or programming generally qualify as depth electives. Mathematics, Statistics, or Economics courses in areas applicable to finance also qualify. Computational Finance majors may have the opportunity to take MSCF courses (as described below) and these may also be counted as depth electives.

There is no definitive list of approved depth electives. The courses listed below have been taken as depth electives in recent years, but other courses could be approved upon request

10-301	Introduction to Machine Learning (Undergrad)	12
10-601	Introduction to Machine Learning (Master's)	12
10-605	Machine Learning with Large Datasets	12
15-150	Principles of Functional Programming	12
15-210	Parallel and Sequential Data Structures and Algorithms	12
15-213	Introduction to Computer Systems	12
15-351	Algorithms and Advanced Data Structures	12
15-451	Algorithm Design and Analysis	12
21-393	Operations Research II	9
21-355	Principles of Real Analysis I	9
21-378	Mathematics of Fixed Income Markets	9
36-402	Advanced Methods for Data Analysis	9
36-410	Introduction to Probability Modeling	9
36-462	Special Topics: Methods of Statistical Learning	9
36-463	Special Topics: Multilevel and Hierarchical Models	9
36-464	Special Topics: Psychometrics: A Statistical Modeling Approach	9
70-391	Finance	9
70-492	Investment Analysis	9
70-495	Corporate Finance	9
70-497	Derivative Securities	9

MSCF Courses

Computational Finance majors are required to take 46-977 MSCF Studies in Financial Engineering. They may also have the opportunity to take up to four more MSCF courses. Permission to enroll in these courses requires (1) approval from the BSCF program, (2) approval of the course instructor, and (3) space available in the course. The MSCF curriculum (https://www.cmu.edu/mscf/academics/curriculum/) with course descriptions is described on the MSCF website (https://www.cmu.edu/mscf/).

Some MSCF courses cover material in the undergraduate curriculum and thus are not generally suitable. Other courses require background that is difficult to obtain as an undergraduate. Students interested in taking MSCF courses are encouraged to discuss their interest with their BSCF advisor as early as possible.

General Education Requirements

Students completing Computational Finance as an additional major will complete the general education requirements from their home department and college. Students completing Computational Finance as their primary major in either MCS or Tepper will complete a modified version of the general education requirements from their home college. These requirements are outlined below.

General Education Requirements for MCS Students

Students in the Mellon College of Science completing the Computational Finance major as their primary major must complete the requirements below in addition to the major requirements.

99-101	Computing @ Carnegie Mellon	3
76-101	Interpretation and Argument	9
or 76-102	Advanced First Year Writing: Special Topics	
or 76-106	Writing about Literature, Art and Culture	
or 76-107	Writing about Data	
or 76-108	Writing about Public Problems	

Technical Breadth Requirement

A student must take at least 18 units of MCS technical breadth courses total, one from “Life Sciences” and one from “Physical Sciences”. AP/IB/Cambridge credit may not be used to fulfill these requirements. CMU placement exam credit can be used to fill these requirements. Transfer courses from an accredited college/university will be considered for these technical breadth requirements. To support educational exploration, courses taken to satisfy BSCF major requirements may not be used to satisfy the general education requirements. Courses that have been approved for each category can be found below.

A. Life Sciences

(Some courses have prerequisites that can be satisfied by AP, IB, Cambridge A Level Exams. Please check the prerequisites requirements as necessary.)

LIFE SCIENCES COURSES		
02-250	Introduction to Computational Biology	12
02-261	Quantitative Cell and Molecular Biology Laboratory	Var.
03-116	Phage Genomics Research * Offered only in Doha	6
03-117	Frontiers, Analysis, and Discovery in Biological Sciences	6
03-121	Modern Biology	9
03-151	Honors Modern Biology	10
03-124	Modern Biology Laboratory	9
03-125	Evolution	9
03-132	Basic Science to Modern Medicine	9
03-133	Neurobiology of Disease	9
03-135	Structure and Function of the Human Body	9
03-161	Molecules to Mind	9
03-231	Honors Biochemistry	9
03-232	Biochemistry I	9
42-101	Introduction to Biomedical Engineering	12
42-202	Physiology	9
85-219	Foundations of Brain and Behavior	9

B. Physical Sciences

(Some courses have prerequisites that can be satisfied by AP, IB, Cambridge A Level Exams. Please check the prerequisites requirements as necessary.)

PHYSICAL SCIENCES COURSES		
09-105	Introduction to Modern Chemistry I	10
09-106	Modern Chemistry II	10
09-107	Honors Chemistry: Fundamentals, Concepts and Applications	10
09-111	Nanolegos: Chemical Building Blocks	9
09-214	Physical Chemistry	9
09-217	Organic Chemistry I	9
09-219	Modern Organic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
09-225	Climate Change: Chemistry, Physics and Planetary Science	9

09-348	Inorganic Chemistry	10
33-121	Physics I for Science Students	12
33-122	Physics II for Biological Sciences & Chemistry Students	9
33-141	Physics I for Engineering Students	12
33-142	Physics II for Engineering and Physics Students	12
33-151	Matter and Interactions I	12
33-152	Matter and Interactions II	12
33-211	Physics III: Modern Essentials	10
33-224	Stars, Galaxies and the Universe	9
33-225	Quantum Physics and Structure of Matter	9

Non-Technical Elective: Cognition, Choice, and Behavior

One of the following:

80-100	Introduction to Philosophy	9
80-130	Introduction to Ethics	9
80-150	Nature of Reason	9
80-180	Nature of Language	9
80-208	Critical Thinking	9
80-220	Philosophy of Science	9
80-221	Philosophy of Social Science	9
80-270	Problems of Mind and Body: Meaning and Doing	9
80-271	Mind and Body: The Objective and the Subjective	9
80-312	Mathematical Revolutions	9
80-330	Ethical Theory	9
85-102	Introduction to Psychology	9
85-211	Cognitive Psychology	9
85-221	Principles of Child Development	9
85-241	Social Psychology	9
85-251	Personality	9
85-261	Psychopathology	9
88-120	Reason, Passion and Cognition	9

Though any of these courses will satisfy the Cognition, Choice, and Behavior requirement, students are strongly encouraged to consider taking one of the ethics courses: 80-130 or 80-330.

Non-Technical Elective: Cultural Analysis

One of the following:

57-173	Survey of Western Music History	9
57-209	The Beatles	9
70-342	Managing Across Cultures	9
76-232	Introduction to Black Literature	9
76-239	Introduction to Film Studies	9
76-241	Introduction to Gender Studies	9
79-104	Global Histories	9
79-202	Flesh and Spirit: Early Modern Europe, 1400-1750	9
79-205	20th Century Europe	9
79-225	West African History in Film	9
79-229	The Origins of the Palestinian-Israeli Conflict, 1880-1948	9
79-230	The Arab-Israeli Conflict and Peace Process since 1948	9
79-240	Development of American Culture	9
79-239	History of the American Working Class	9
79-241	African American History: Africa to the Civil War	9
79-242	African American History: Reconstruction to the Present	9
79-261	The Last Emperors: Chinese History and Society, 1600-1900	9
79-265	Russian History: Game of Thrones	9
79-266	Russian History and Revolutionary Socialism	9
79-281	Introduction to Religion	9
79-345	Roots of Rock & Roll	9
79-350	Early Christianity	9
80-100	Introduction to Philosophy	9
80-250	Ancient Philosophy	9
80-251	Modern Philosophy	9
80-253	Continental Philosophy	9
80-254	Analytic Philosophy	9
80-255	Pragmatism: Making Ideas Work	9
80-261	Experience, Reason, and Truth	9
80-276	Philosophy of Religion	9
82-xxx	Any courses from Modern Languages	

Non-Technical Electives: Two Additional Courses

In addition to the Cognition, Choice and Behavior and the Cultural Analysis requirements, majors in MCS must take two more courses (at least 18 units) from any of the departments in DC, CFA or Tepper, subject to the list of deletions (https://www.cmu.edu/mcs/undergrad/advising/hss-finearts/deletions.html) and additions (https://www.cmu.edu/mcs/undergrad/advising/hss-finearts/additions.html) maintained by MCS.

Additional Notes

BSCF majors in MCS may use AP credits to satisfy nontechnical general education requirements. However, students cannot count more than 18 units from AP/IB/Cambridge exam credit towards these requirements. Transfer courses from an accredited college/university will be considered for these nontechnical breadth requirements. To support educational exploration, courses taken to satisfy BSCF major requirements may not be used to satisfy the general education requirements.

General Education Requirements for Tepper Students

Students in the Tepper School of Business completing the Computational Finance major as their primary major must complete the requirements below in addition to the major requirements.

Tepper Functional Business Core

Computational Finance majors whose home college is Tepper will complete a modified version of the Tepper Functional Business Core curriculum.

The Functional Business Core of the Undergraduate Business Administration Program includes 70-122 Introduction to Accounting, which is required by all Computational Finance majors. It also includes 70-391 Finance, which Tepper students majoring in Computational Finance must select as of one their Depth Electives. In addition, Tepper students pursuing the B.S. in Computational Finance must complete six other courses from the Functional Business Core.

These courses are:

70-106	Business Science	9
70-311	Organizational Behavior	9
70-332	Business, Society and Ethics	9
70-371	Operations Management	9
70-381	Marketing I	9
70-401	Management Game	12

Liberal Arts & Sciences Breadth Requirements

Candidates for the B.S. in Computational Finance must complete the Liberal Arts & Sciences Breadth Requirements as described in the catalog entry for the B.S. Degree in Business Administration.

Sample Curricula

MCS Sample Curriculum

What follows is the detailed curriculum for the degree Bachelor of Science in Computational Finance in the Mellon College of Science. This is an example of how an MCS student might meet the requirements of the Computational Finance major. It is not expected that every student will follow this sequence. In particular, well prepared students should consider taking 21-270 Introduction to Mathematical Finance during their Freshman Spring semester. Students intending to do so are encouraged to take 21-127

Concepts of Mathematics or 21-241 Matrices and Linear Transformations during their Freshman Fall semester.

Freshman	
Fall	**Spring**
15-110 Principles of Computing	15-112 Fundamentals of Programming and Computer Science
21-120 Differential and Integral Calculus	21-122 Integration and Approximation
76-101 Interpretation and Argument	70-122 Introduction to Accounting
99-101 Computing @ Carnegie Mellon	xx-xxx Science Requirement
xx-xxx Science Requirement	xx-xxx Elective

Sophomore	
Fall	**Spring**
21-241 Matrices and Linear Transformations	21-270 Introduction to Mathematical Finance
21-259 Calculus in Three Dimensions	21-127 Concepts of Mathematics
21-260 Differential Equations	21-369 Numerical Methods
73-102 Principles of Microeconomics	73-103 Principles of Macroeconomics
xx-xxx Humanities, Social Sciences, or Fine Arts Elective	xx-xxx Elective

Junior	
Fall	**Spring**
21-325 Probability	21-420 Continuous-Time Finance
21-370 Discrete Time Finance	36-226 Introduction to Statistical Inference
73-240 Intermediate Macroeconomics	xx-xxx Humanities, Social Sciences, or Fine Arts Elective
15-122 Principles of Imperative Computation	xx-xxx Humanities, Social Sciences, or Fine Arts Elective
xx-xxx Elective	xx-xxx Depth Elective

Senior	
Fall	**Spring**
46-977 MSCF Studies in Financial Engineering	95-717 Writing for Information Systems Management
94-700 Organizational Design & Implementation	95-718 Professional Speaking
36-401 Modern Regression	xx-xxx Depth Elective
xx-xxx Depth Elective	xx-xxx Humanities, Social Sciences, or Fine Arts Elective
xx-xxx Elective	xx-xxx Elective
xx-xxx Elective	xx-xxx Elective

Tepper Sample Curriculum

What follows is the detailed curriculum for the degree Bachelor of Science in Computational Finance in the Tepper School of Business. This is an example of how a Tepper student might meet the requirements of the Computational Finance major. It is not expected that every student will follow this sequence. In particular, well prepared students should consider taking 21-270 Introduction to Mathematical Finance during their Freshman Spring semester. Students intending to do so are encouraged to take 21-127 Concepts of Mathematics or 21-241 Matrices and Linear Transformations during their Freshman Fall semester.

Freshman	
Fall	**Spring**
15-110 Principles of Computing	15-112 Fundamentals of Programming and Computer Science
21-120 Differential and Integral Calculus	21-122 Integration and Approximation
73-102 Principles of Microeconomics	21-241 Matrices and Linear Transformations
70-106 Business Science	73-103 Principles of Macroeconomics
76-101 Interpretation and Argument	xx-xxx Breadth Course
99-101 Computing @ Carnegie Mellon	xx-xxx Breadth Course

Sophomore	
Fall	**Spring**
21-127 Concepts of Mathematics	21-270 Introduction to Mathematical Finance
21-259 Calculus in Three Dimensions	21-325 Probability
21-260 Differential Equations	70-311 Organizational Behavior
70-122 Introduction to Accounting	70-381 Marketing I
xx-xxx Elective	73-240 Intermediate Macroeconomics

Junior	
Fall	**Spring**
21-369 Numerical Methods	21-420 Continuous-Time Finance
21-370 Discrete Time Finance	36-226 Introduction to Statistical Inference
70-391 Finance	70-371 Operations Management
15-122 Principles of Imperative Computation	xx-xxx Breadth Course
xx-xxx Breadth Course	xx-xxx Breadth Course

Senior	
Fall	**Spring**
36-401 Modern Regression	95-717 Writing for Information Systems Management
46-977 MSCF Studies in Financial Engineering	95-718 Professional Speaking
70-332 Business, Society and Ethics	xx-xxx Depth Elective
70-401 Management Game	xx-xxx Breadth Course
xx-xxx Depth Elective	xx-xxx Breadth Course
	xx-xxx Elective

Minor in Computational Finance

Unlike the major in Computational Finance, there is no application process for the minor in Computational Finance, however in order to declare the minor in Computational Finance, a student must satisfy one of the following sets of requirements:

1. Completion of 21-270 Introduction to Mathematical Finance with a grade of A and an overall QPA of at least 3.20; OR
2. Completion of 21-270 Introduction to Mathematical Finance and 21-370 Discrete Time Finance with an average grade of B and an overall QPA of at least 3.00; OR
3. Completion of 21-270 Introduction to Mathematical Finance and 21-378 Mathematics of Fixed Income Markets with an average grade of B and an overall QPA of at least 3.00.

When a student has met the necessary requirements, he or she may declare the minor by contacting the Associate Director of the Undergraduate Computational Finance program.

> ***Note:*** *For students who have a grade of P in either 21-270 or 21-378 from the Spring 2020 semester (and only that semester) these requirements have been altered slightly. The grade of P will not be counted toward the averages in conditions 2 or 3. This effectively makes the requirements*
>
> *1. Completion of* 21-270 Introduction to Mathematical Finance *with a grade of A and an overall QPA of at least 3.20; OR*
>
> *2. Completion of* 21-270 Introduction to Mathematical Finance *and* 21-370 Discrete Time Finance *with an average grade of B and an overall QPA of at least 3.00; OR*
>
> *2a. Completion of* 21-270 Introduction to Mathematical Finance *with a grade of P in Spring 2020, and completion of* 21-370 Discrete Time Finance *with a minimum grade of B and an overall QPA of at least 3.00; OR*
>
> *3. Completion of* 21-270 Introduction to Mathematical Finance *and* 21-378 Mathematics of Fixed Income Markets *with an average grade of B and an overall QPA of at least 3.00; OR*
>
> *3a. Completion of* 21-270 Introduction to Mathematical Finance *with a grade of P in Spring 2020, and completion of* 21-378 Mathematics of Fixed Income Markets *with a minimum grade of B and an overall QPA of at least 3.00.*

21-241	Matrices and Linear Transformations	11
or 21-242	Matrix Theory	
21-259	Calculus in Three Dimensions	9-11
or 21-256	Multivariate Analysis	
or 21-268	Multidimensional Calculus	
or 21-269	Vector Analysis	
21-260	Differential Equations	9-10
or 21-261	Introduction to Ordinary Differential Equations	
21-270	Introduction to Mathematical Finance	9
21-370	Discrete Time Finance *	9
21-420	Continuous-Time Finance **	9

To avoid excessive double counting, Computational Finance minors may not count 21-270 Introduction to Mathematical Finance, 21-370 Discrete Time Finance or 21-420 Continuous-Time Finance toward any other requirement.

* The prerequisites for 21-370 are 21-270 and either 21-256 or 21-259 , and the co-requisite is 70-207 , 21-325 , 36-225 or 36-217. Note that 70-207 is not accepted as a prerequisite for 21-420.

** The prerequisites for 21-420 are 21-260 , 21-370 and one of the following three calculus based probability courses: 21-325 , 36-225 or 36-217 . Note that 70-207 is not a sufficient preparation in probability. Also note that 21-122 is a prerequisite for 21-260 and that 21-127 is recommended for 21-241 .

Students minoring in Computational Finance are strongly encouraged to take one or two economics course, e.g., 73-102, 73-103, 73-230 , or 73-240 .

Environmental & Sustainability Studies

Program in Environmental and Sustainability Studies

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Abigail Owen, Program Director & Program Faculty, Minor and
 Additional Major in Environmental & Sustainability Studies
Ryan Sullivan, Program Faculty, Minor and Additional Major in
 Environmental & Sustainability Studies
Neil Donahue, Director, Steinbrenner Institute for Environmental
 Education and Research
Joe Moore, Co-Advisor, Minor and Additional Major in Environmental &
 Sustainability Studies
Kathy Zhang, Program Assistant
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https://www.cmu.edu/steinbrenner/undergraduate-program/index.html (https://www.cmu.edu/steinbrenner/undergraduate-program/)

Maggie Braun, Associate Dean for Undergraduate Affairs, Mellon College of Science
Sharon Carver, Associate Dean for Educational Affairs, Marianna Brown Dietrich College of Humanities & Social Sciences

The Steinbrenner Institute for Environmental Education & Research, the Dietrich College of Humanities & Social Sciences, and the Mellon College of Science have joined together to establish the interdisciplinary Program in Environmental & Sustainability Studies, offering a Minor or an Additional Major.

The Minor and Additional Major in Environmental & Sustainability Studies are designed to be accessible for any undergraduate student at Carnegie Mellon University, regardless of primary major and college, and without extensive prerequisite barriers. Building from core coursework, students can tailor their elective coursework, with intensive guidance from program advisors, to integrate appropriate electives from a wide range of possible courses to develop a coherent course of study with appropriate depth and breadth.

Additional Major in Environmental and Sustainability Studies

The additional major is designed to allow students from any college at CMU to build on the depth of their primary major and address the breadth of intrinsically interdisciplinary issues associated with the environment and sustainability.

There is no application process for the program in Environmental and Sustainability Studies, however a student must declare the Minor or Additional Major by contacting the Advisor or Program Director of the Environmental and Sustainability Studies program. Due to limited enrollment for a small class size in core course 66-236 “Introduction to Environmental Ideas” (9 Units), students are encouraged to declare the Minor or Additional Major as early as possible, so they can receive priority in course registration.

The Additional Major combines natural science, social science, and humanistic studies. These are co-equal. How Earth functions as a system is fundamental: key topics include climate, ecosystems, environmental chemistry (the behavior of molecules within the environment) and energy systems. Human interactions with the environment, and so the details of how cultural, political, and social systems function, are critical to understand, with an emphasis on sustainability and the environment. Issues of ethics, equity, and justice, situated in historical context, are vital to a full and complex understanding with a goal of equitable and appropriate solutions to environmental crises.

The three pillars are:

1. Earth and Environmental Science. Majors should understand how the Earth works as a system, with more advanced understanding of selected scientific topics associated with Environment and Sustainability.
2. Political Economy. Majors should understand the consequences and options of economics and policy at the local, regional, and global level.
3. Humanities for Environment and Sustainability. Additional Majors should understand cultural, social, historical, ethical, and political aspects of environment and sustainability, including environmental, climate, and social justice.

Students who pursue the Additional Major will be able to:

- Apply humanistic, social, and scientific perspectives for problems of environment and sustainability
- Distinguish among scientific methods for evaluating problems of environment and sustainability
- Explain how aspects of history, culture, ethics, language, and arts relate to environment and sustainability, including goals for environmental justice and global climate justice.
- Assess sources of data about environment and sustainability
- Formulate a research question for interdisciplinary studies of environment and sustainability. Identify discipline-specific methods for exploring or answering the questions posed and use the chosen methods to gather and analyze evidence

Double-Counting

Maximum 3 courses, regardless of Units, can be double-counted for the Additional Major from any other Minor, Major, or Master’s program. This maximum does not apply to General Education courses.

General Education courses

Courses taken to fulfill a General Education requirement for the student’s college (the college of the student's primary major) are not calculated as “double-counting” for the Additional Major in Environmental and Sustainability Studies.

AP credit

AP courses are not counted towards requirements for the Additional Major in Environmental and Sustainability Studies.

Study abroad

Courses taken abroad may count towards Electives for the Additional Major, if accepted for transfer credit by the relevant CMU department and approved by the Program Director.

Requirements for the Additional Major in Environmental & Sustainability Studies

- **Minimum 102 Units Total for students with primary majors in CFA, Dietrich, Tepper**
- **Minimum 105 Units Total for students with primary majors in MCS, Engineering, SCS**

Core Courses: Complete 27 Units for students with Primary majors in CFA, Dietrich, Tepper; Complete 30 Units for Students with Primary Majors in MCS, Engineering, SCS		Units
24-291	Environmental Systems on a Changing Planet Cross-listed as 09-291	9
24-381	Environmental Systems on a Changing Planet: Science & Engineering Addendum Cross-listed as 09-381. This 3-unit addendum course is required for students with primary majors in MCS, Engineering, or SCS.	3
66-236	Introduction to Environmental Ideas	9
66-506	Senior Capstone	9

Earth and Environmental Science - Complete any one (minimum 9 Units)		Units
03-128	Biology for Life Special Topics Section S, "Tropical Ecology" (9 units) offered at CMU Study Abroad Program in Costa Rica; Without prerequisite	9
03-140	Ecology and Environmental Science Without prerequisite	9
33-115	Physics for Future Presidents Without prerequisite	9
09-225	Climate Change: Chemistry, Physics and Planetary Science	9
09-510	Chemistry and Sustainability	9
09-524	Environmental Chemistry	9
09-529	Introduction to Sustainable Energy Science	9
09-538	Exposure and Risk Assessment for Environmental Pollutants	9
33-226	Physics of Energy	9

Global Course - Complete any one (3 Units)		Units
99-384	Technology, Humanity, and Social Justice: Health Each semester, a new 3-Unit course 99-xxx is offered on Global themes, in partnership with University of Pittsburgh's Global Studies Center.	3

Statistics & Data Science - Complete 9 Units		Units
36-200	Reasoning with Data This requirement can only be fulfilled with a course taken in the Department of Statistics & Data Science at CMU. AP Statistics does not fulfill this requirement. Students with AP credit can place into a higher-level course offered by the same Department, for example 36-202 or 36-290.	9

Political Economy - Complete any one (Minimum 9 Units)		Units
19-101	Introduction to Engineering and Public Policy Without prerequisite	12
79-300	History of American Public Policy Without prerequisite	9
84-110	Foundations of Political Economy Without prerequisite	9
84-226	International Relations Without prerequisite	9
84-325	Contemporary American Foreign Policy Without prerequisite	9
88-344	Systems Analysis: Environmental Policy Without prerequisite	9
73-332	Political Economy	9
73-408	Law and Economics	9
73-427	Sustainability, Energy, and Environmental Economics	9
84-310	International Political Economy	9
88-221	Markets, Democracy, and Public Policy	9
88-366	Behavioral Economics of Poverty and Development	9

Electives for Environmental & Sustainability Studies - Complete 45 Units

For the Additional Major, select and complete at least 45 Units of eligible electives in consultation with the Program Advisor and/or Program Director. At least 36 out of 45 Units of Electives for the Additional Major should be "External electives" completed outside of the college where the student's primary major is housed; this is to encourage students to pursue interdisciplinary breadth. The remaining 9 Units of Electives for the Additional Major are "Free electives" from any college, including the student's own primary college.

Example

A student with a primary Major in Art (College of Fine Arts) could complete up to 9 Units of Electives for the Additional Major within the College of Fine Arts. This means up to 9 Units of Electives could be taken in Music, Design, Architecture, Drama, or Art; the remaining 36 Units of Electives must come from outside CFA: from Dietrich, Engineering, Business, or Science.

Electives are vetted by the program director from the CMU course catalog and listed each term based on the following criteria. Additional courses meeting these criteria can be approved by the program director.

Additional courses from these categories always count as electives:

- Any additional courses listed in the above category "Earth and Environmental Science" can be counted as electives.
- Any additional courses listed in the above category "Political Economy" can be counted as electives.
- Any additional courses listed in the above category "Global Course" can be counted as electives.

Any further electives should:

- Broaden the reach of the student's interdisciplinary explorations in environment and sustainability
- Thematically, courses should either add to depth from above-listed categories: "Earth and Environmental Science"; "Environmental Humanities"; "Three Unit Global Course"; and/or "Political Economy";
- Or, electives should increase the student's interdisciplinary grasp of topics related to environment and sustainability, with particular emphasis on topics related to environmental justice and/or global climate justice.

Minor in Environmental and Sustainability Studies

There is no application process for the program in Environmental and Sustainability Studies, however a student must declare the Minor or Additional Major by contacting the Advisor or Program Director of the Environmental and Sustainability Studies program. Due to limited enrollment for a small class size in core course 66-236 "Introduction to Environmental Ideas" (9 Units), students are encouraged to declare the Minor or Additional Major as early as possible, so they can receive priority in course registration.

Students who pursue the minor will be able to:

- Identify humanistic, social, and scientific perspectives for problems of environment and sustainability
- Distinguish among scientific methods for evaluating problems of environment and sustainability
- Connect how aspects of history, culture, ethics, language, and arts relate to environment and sustainability, including goals for environmental justice and global climate justice
- Discuss sources of data about environment and sustainability

Double-Counting

Maximum 2 courses, regardless of Units, can be double-counted for the Minor from any other Minor, Major, or Master's program. This maximum does not apply to General Education courses.

General Education courses

Courses taken to fulfill a General Education requirement for the student's college (the college of the student's primary major) are not calculated as "double-counting" for the Minor in Environmental and Sustainability Studies.

AP credit

AP courses are not counted towards requirements for the Minor in Environmental and Sustainability Studies.

Study abroad

Courses taken abroad may count towards Electives for the Minor, if accepted for transfer credit by the relevant CMU department and approved by the Program Director.

Requirements for the Minor in Environmental & Sustainability Studies

- **Minimum 66 Units Total for students with primary majors in CFA, Dietrich, Tepper**
- **Minimum 69 Units Total for students with primary majors in MCS, Engineering, SCS**

Core Courses: Complete 18 Units for students with Primary majors in CFA, Dietrich, Tepper; Complete 21 Units for Students with Primary Majors in MCS, Engineering, SCS		Units
24-291	Environmental Systems on a Changing Planet Cross-listed as 09-291	9
24-381	Environmental Systems on a Changing Planet: Science & Engineering Addendum Cross-listed as 09-381. This 3-unit addendum course is required for students with primary majors in MCS, Engineering, or SCS.	3
66-236	Introduction to Environmental Ideas	9

Global Course - Complete any one (3 Units)		Units
99-384	Technology, Humanity, and Social Justice: Health	3

Statistics & Data Science - Complete 9 Units		Units
36-200	Reasoning with Data This requirement can only be fulfilled with a course taken in the Department of Statistics & Data Science at CMU. AP Statistics does not fulfill this requirement. Students with AP credit can place into a higher-level course offered by the same Department, for example 36-202 or 36-290.	9

Electives for Environmental & Sustainability Studies - Complete 36 Units

For the Minor, select and complete at least 36 Units of eligible electives in consultation with the Program Advisor and/or Program Director. At least 27 out of 36 Units of Electives for the Minor should be "External electives" completed outside of the college where the student's primary major is housed; this is to encourage students to pursue interdisciplinary breadth. The remaining 9 Units of Electives for the Minor are "Free electives" from any college, including the student's own primary college.

Example

A student with a primary Major in Art (College of Fine Arts) could complete up to 9 Units of Electives for the Minor within the College of Fine Arts. This means up to 9 Units of Electives could be taken in Music, Design, Architecture, Drama, or Art; the remaining 27 Units of Electives for the Minor must come from outside CFA: from Dietrich, Engineering, Business, or Science.

Electives are vetted by the program director from the CMU course catalog and listed each term based on the following criteria. Additional courses meeting these criteria can be approved by the program director.

Additional courses from these categories always count as electives:

- Any additional courses listed in the above category "Earth and Environmental Science" (see Additional Major requirements) can be counted as electives.
- Any additional courses listed in the above category "Political Economy" (see Additional Major requirements) can be counted as electives.
- Any additional courses listed in the above category "Global Course" can be counted as electives.

Any further electives should:

- Broaden the reach of the student's interdisciplinary explorations in environment and sustainability
- Thematically, courses should either add to depth from above-listed categories: "Earth and Environmental Science"; "Environmental Humanities"; "Three Unit Global Course"; and/or "Political Economy";
- Or, electives should increase the student's interdisciplinary grasp of topics related to environment and sustainability, with particular emphasis on topics related to environmental justice and/or global climate justice.

Game Design Minor – IDeATe

The *Game Design* minor is offered by the Entertainment Technology Center (http://coursecatalog.web.cmu.edu/intercollegeprograms/etc.cmu.edu) as part of the Integrative Design, Arts and Technology (http://coursecatalog.web.cmu.edu/intercollegeprograms/ideate.cmu.edu) (IDeATe) network. IDeATe offers students the opportunity to become immersed in a collaborative community of faculty and peers who share expertise, experience, and passions at the intersection of arts and technology. Students will engage in active "learning by doing" in shared labs and maker spaces. The program addresses current and emerging real-world challenges that require disciplinary expertise coupled with multidisciplinary perspectives and collaborative integrative approaches.

The IDeATe undergraduate curriculum consists of ten areas, all of which can also be taken as minors. The themes of these areas integrate knowledge in technology and arts: Game Design, Animation & Special Effects, Media Design, Design for Learning, Sonic Arts, Innovation and Entrepreneurship, Intelligent Environments, Physical Computing, Soft Technologies, and Immersive Technologies in Arts & Culture. For more information about the IDeATe network, please visit Undergraduate Options (http://coursecatalog.web.cmu.edu/aboutcmu/undergraduateoptions/#ideate).

Game design is an art, a craft, and a science. Students in the IDeATe *Game Design* minor will gain mastery in all three aspects through game design, development, and assessment. You will learn about the rich histories, theory, and practice of game creation taught by faculty experts, and have opportunities to collaborate across the many disciplines needed to make successful game experiences. Through coursework you will be able to realize your own unique aesthetics and voice by reflecting on your own game play and by thoughtfully critiquing the games of others. Through the minor students will be able to build a strong game design portfolio, deepen cultural sensitivities as a game designers, and expand their creative practice. In particular, you will gain skills and competencies in the following areas of game design:

- Game systems and mechanics design
- Interactive narrative and character development
- Visual and audio asset creation
- Game programming
- Interface design and user testing
- Collaboration and the iterative design process

Curriculum

One Computing Course - Minimum of 9 Units

		Units
15-104	Introduction to Computing for Creative Practice	10
15-110	Principles of Computing	10
15-112	Fundamentals of Programming and Computer Science	12
60-212	Intermediate Studio: Creative Coding	12

One IDeATe Portal Course - Minimum of 9 Units

		Units
16-223	IDeATe Portal: Creative Kinetic Systems	10
18-090	Twisted Signals: Multimedia Processing for the Arts	10
53-322	IDeATe: Little Games/Big Stories: Indie Roleplaying Game Studio Recommended Portal Course for this area	9
60-125	IDeATe: Introduction to 3D Animation Pipeline	12
60-218	IDeATe Portal: Real-Time Animation	10
60-223	IDeATe Portal: Introduction to Physical Computing	10

62-150	IDeATe Portal: Introduction to Media Synthesis and Analysis Recommended Portal Course for this area	10
82-250	Digital Realities: Introducing Immersive Technologies for Arts and Culture	9
99-361	IDeATe Portal	9

IDeATe Game Design Courses - Minimum of 27 Units

		Units
05-418	Design Educational Games	12
05-499	Special Topics in HCI For sections related to Game Design	12
15-466	Computer Game Programming	12
53-230	Programming for Game Designers	12
53-320	IDeATe Special Topics in Animation: Character Modeling	6
53-321	IDeATe Special Topics in Animation: Bipedal Rigging for Animation Production	6
53-322	IDeATe: Little Games/Big Stories: Indie Roleplaying Game Studio	9
53-323	IDEATE Storytelling Through Effects Animation	6
53-353	Understanding Game Engines	9
53-371/76-368	Role Playing Games Writing Workshop	12
53-373	Dynamic Motion and Game Experience	12
53-451	Research Issues in Game Development: Designing for XR	12
53-471	Game Design, Prototyping and Production	15
53-472	Advanced Game Studio	12
53-558	Reality Computing Studio	12
60-333	IDeATe: Animation Rigging	10
60-419	Advanced ETB: Experimental Game Studio: Digital Playgrounds	10

Additional courses as available. Please refer to the IDeATe website for the list of Game Design courses for the currnent and upcoming semesters.

Double-Counting

Students may double-count up to two of their *Game Design* minor courses toward requirements for other majors or minors.

Major in General Studies

The Bachelor of Arts and Bachelor of Science in General Studies provide students a pathway through a broad educational foundation while adhering to the strong standards of a CMU degree.

The General Studies major covers both intercollegiate breadth and discipline-specific knowledge. The intercollegiate educational requirements expose students to a variety of intellectual and cultural approaches and provide serviceable knowledge on a range of topics. In addition to this liberal arts style foundation, students are required to declare and complete an academic minor. This concentrated study equips students with in-depth knowledge of a given professional field. Students are challenged to move beyond base assumptions and to demonstrate higher order creativity, analysis, and application. Additionally, the academic minor sends a concrete signal to future employers to indicate areas of interest and experience: “BA/BS in General Studies” also requires a “Minor in X”. Near the end of their degree, General Studies students synthesize their educational pursuits. They are required to register for a 3+ unit Independent Study/Capstone to create a culminating project/paper. This course requires a supervising faculty advisor and is presented at Meeting of the Minds or an equivalent pre-approved public forum.

Eligibility and approval

A student cannot independently pursue this degree. Any student expressing interest in transferring to the General Studies major must discuss their motivation and alternative options with their academic advisor, receive approval from their college’s Assistant/Associate Dean, and then be approved by the General Studies Academic Advisory Committee. Students must work with their Assistant/Associate Dean to first exhaust the following options:

- maintaining their current degree path,
- changing majors in one’s home college, or
- transferring to another college at CMU.

In order to be considered for the General Studies major program, a student must fulfill all of the criteria:

1. A student must have successfully completed at least 180 units, 75% of which were completed at CMU.
2. A student must have passed the University’s general education requirements: “First-Year Writing” and “Computing at CMU.” See table below for full listing of courses that can satisfy these requirements.
3. A student must demonstrate the ability to be successful in their intended minor. Students must be on track to complete at least 50% of the minor’s coursework at the point of application.
4. A student must create both a Success Plan and Curricular Plan with their advisor. This plan must include monthly meetings with their academic advisor, outline a plan for continual satisfactory academic progress, and be approved by their Assistant/Associate Dean.

If all the above criteria are met, each student’s case is brought to the General Studies Academic Advisory Committee and must receive a majority vote to advance.

Degree Structure and Graduation Requirements

In accordance with Carnegie Mellon’s standards and degree norms, all candidates must complete the following requirements in order to graduate with a General Studies major:

1. Apply and be approved by the General Studies Academic Advisory Committee as a General Studies Major.
2. Adhere to and make progress toward the agreed upon Success and Curricular plans.
3. Declare and complete an academic minor in your home college or gain approval and complete a minor in another college. (Transfer credit acceptance will be determined by the equivalent CMU department). Additional minors beyond the General Studies degree with a minor in x will not be considered unless the secondary minor’s units are in addition to all of the General Studies degree requirements.
4. Graduation requirements are broadly defined as follows, and outlined in the following “Curriculum” section:
   a. Earn a minimum of 360 units.
   b. Students may count up to 40 non-factorable units with a maximum of 9 total non-factorable units of StuCo, ROTC, and P/E.
   c. Students must have a minimum of 45 units in upper level courses, as defined by the course’s home department (generally 300 level or above).
   d. Pass/fail courses may not be used for the primary major or minor requirements (for courses that are otherwise letter graded). Pass/fail courses may not be used for the general education requirements of the degree.
   e. Earn a QPA of at least 2.0 for all courses taken (For undergraduate students who enrolled at Carnegie Mellon as freshmen and whose freshman grades cause the cumulative QPA to fall below 2.00, this requirement is modified to be a cumulative QPA of at least 2.00 for all courses taken after the freshman year.)

Curriculum

Minimum units required for B.A./B.S. in General Studies 360

Seminar requirement

99-430	General Studies Capstone Course	**3-12, variable**

First-year writing REQUIREMENT

Complete a total of 9 units from the following courses.

76-101	Interpretation and Argument	9
76-102	Advanced First Year Writing: Special Topics	9
76-106	Writing about Literature, Art and Culture	4.5
76-107	Writing about Data	4.5
76-108	Writing about Public Problems	4.5

general studies REQUIREMENTs

99-101	Computing @ CMU	**3**
Breadth coursework	Minimum of 18 units in each of three different CMU school/colleges covering at least five departments (this can include the school/ department that the student is currently enrolled in).	**54 units**

The courses used to satisfy the breadth requirement must be in addition to the minimum total of 45 units in upper level courses required for the major.

MIDDLE STATES REQUIREMENTS

General Studies students should have a well-rounded education that fulfills Middle States Accreditation requirements, demonstrating learning in each of seven categories. Students will work with their advisor and associate dean (or equivalent) to guarantee that each category is fulfilled, recognizing what they have done while exploring other degrees across departments and colleges. Courses counting for their major and/or minor can be used to fulfill these requirements.

Communication (oral, written, and visual)	**Variable units**
Information literacy	**Variable units**
Critical thinking	**Variable units**
Cultural and social understanding	**Variable units**
Personal development	**Variable units**
Quantitative reasoning	**Variable units**
Scientific reasoning	**Variable units**

Minor in Immersive Technologies in Arts & Culture

Students in the Immersive Technologies in Arts & Culture (https://ideate.cmu.edu/undergraduate-programs/immersive-technologies-in-arts-culture/) minor will be hybrid technologists, media-makers, and storytellers who can create mediated experiences at the intersection of technology, design, and the humanities. They will be equipped with the social consciousness, global awareness, and cross-cultural skills needed to forge positive new paths for immersive media going into the future.

Students in the minor will learn to construct and deconstruct immersive and augmented experiences with respect to the cultural, socio-emotional, and embodied aspects of human experience. They will develop the technical know-how and creative production skills to collaboratively author original narratives and prototype spatially mediated experiences. In the making of augmented and immersive media, students will explore the narrative possibilities and technical affordances of the genre while attending to the aesthetic considerations, humanistic concerns, and design conventions defining this emerging mode of cultural production.

One IDEATE Portal Course (minimum of 9 units):

82-250	Digital Realities: Introducing Immersive Technologies for Arts and Culture	9

One Intercultural Focus Course (minimum of 9 units):

82-280	Billingual & Bicultural Experiences in the US	9
82-282	Interpreting Global Texts & Cultures	9
82-283	Language Diversity & Cultural Identity	9

One Computing Course (minimum of 9 units):

15-104	Introduction to Computing for Creative Practice	10
15-110	Principles of Computing	10
15-112	Fundamentals of Programming and Computer Science	12
60-212	Intermediate Studio: Creative Coding	12

IDeATe Immersive Technologies Courses (minimum of 27 units)*:

15-365	Experimental Animation	12
or 60-422	Advanced ETB: Experimental Animation	
15-463	Computational Photography	12
53-353	Understanding Game Engines	9
53-373	Dynamic Motion and Game Experience	12
53-376	360 Story and Sound	12
53-451	Research Issues in Game Development: Designing for XR	12
53-558	Reality Computing Studio	12
54-397	Sound Design For Interactive Environments	9
54-399	Decoding Media	9
60-413	Advanced ETB: Real-Time Animation	10
82-284	Multicultural Pittsburgh: VR Storytelling	9
82-287	Multicultural Immersion - Relating Your World in Virtual Reality	6

**Additional courses are available. Please check* IDeATe Courses *(*https://ideate.cmu.edu/courses/current-courses.html*) for the options for the current and upcoming semester.*

Double-counting: Students may double-count up to two of their IDeATe minor courses for other requirements.

Minor in Health Care Policy and Management

Sponsored by:
Heinz College of Information Systems and Public Policy
Dietrich College of Humanities and Social Sciences
Mellon College of Science

Faculty Advisors:
Jason D'Antonio, Mellon College of Science
James F. Jordan, H. John Heinz III College

The face of health care is changing. The practice of medicine is being fundamentally altered by the forces of change in public policy, health care organizations and in the industry as a whole. The role of individual professionals in this industry is changing as rapidly as the industry itself. Traditional career paths have disappeared overnight to be replaced by new opportunities that require new skills. New organizations are placing new demands on their professional and medical staffs. The criteria of efficiency and financial stability are entering the domains of diagnosis and treatment.

This minor is designed to provide students considering a career in the health professions with an understanding of how these changes are likely to affect their careers. Students will become familiar with the critical policy and management issues and will begin to learn to operate effectively in the emerging health care environment. The curriculum combines economic, organizational, managerial, historical and psychological perspectives on these issues to provide a foundation for a deepened understanding of the changing structure of health care organizations and policy.

Required Courses for HCPM Minor

A total of 54 units are required to complete this minor. Entry into the minor requires completion of 73-102 Principles of Microeconomics or the equivalent by approval.

Required Courses

Complete a total of 21 units from the following:

79-330	Medicine and Society: Health, Healers, and Hospitals	9
90-436	Health Systems	6
90-472	Health Policy	6

Elective Courses

Complete a minimum of 24 units from these two sections:

Heinz College Courses		
94-409	Healthcare Information Systems	12
73-328	Health Economics	12
90-832	Health Law	6
90-433	Population Health	6

90-834	Health Care Geographical Information Systems	12
Other courses as approved		

Humanities and Social Sciences Courses (9 units each)		
80-245	Medical Ethics	9
76-494	Healthcare Communications	9
88-365	Behavioral Economics and Public Policy	9
42-444	Medical Devices	9
Other courses as approved		

Please note that some of these courses have prerequisites that will not count toward the completion of the requirements for this minor.

Elective Focus Areas

Focus areas are suggested groupings of electives based on student interest. Students *do not* need to take all electives within one focus area; they are free to choose their 18-unit elective minimum from any combination of focus areas.

Health Management/Administration Focus		Units
90-832	Health Law	6
80-245	Medical Ethics	9
76-494	Healthcare Communications	9

Health Policy Focus		Units
73-328	Health Economics	12
90-832	Health Law	6
90-433	Population Health	6
88-365/90-882	Behavioral Economics and Public Policy	9
Other courses as approved		

Health Analytics & IT Focus		Units
94-409	Healthcare Information Systems	12
90-834	Health Care Geographical Information Systems	12
42-444	Medical Devices	9
Other courses as approved		

B.S. in Psychology & Biological Sciences

Veronica Hinman, *Department Head, Biological Sciences*

Michael Tarr, *Department Head, Psychology*

This major is intended to reflect the interdisciplinary nature of current research in the fields of biology and psychology, as well as the national trend in some professions to seek individuals broadly trained in both the social and natural sciences.

Note: Students entering from the Dietrich College of Humanities and Social Sciences will earn a Bachelor of Science in Psychology and Biological Sciences. Students in the Mellon College of Science will earn a Bachelor of Science in Biological Sciences and Psychology.

Depending on a student's home college (DC or MCS), General Education (GenEd) requirements will be different. GenEd requirements for DC (http://coursecatalog.web.cmu.edu/schools-colleges/dietrichcollegeofhumanitiesandsocialsciences/#hampssgeneraleducationprogram160) and MCS (http://coursecatalog.web.cmu.edu/schools-colleges/melloncollegeofscience/) are found on their respective Catalog pages.

Degree Requirements:

Biological Sciences		Units
03-151	Honors Modern Biology	10
or 03-121	Modern Biology	
03-220	Genetics	9
or 03-221	Genomes, Evolution, and Disease: Introduction to Quantitative Genetic Analysis	
03-231	Honors Biochemistry	9
03-320	Cell Biology	9
03-343	Experimental Techniques in Molecular Biology	12
03-411	Topics in Research	1
03-412	Topics in Research	1
03-xxx	General Biology Elective [1]	9
03-3xx	Advanced Biology Elective [1]	18
Total Biology units		**78**

[1] Please see description and requirements for electives under the B.S. in Biological Sciences section of this Catalog.

Mathematics, Statistics, Physics and Computer Science		Units
21-120	Differential and Integral Calculus	10
21-124	Calculus II for Biologists and Chemists	10
or 21-122	Integration and Approximation	
36-200	Reasoning with Data	9
36-309	Experimental Design for Behavioral & Social Sciences	9
or 85-309	Statistical Concepts and Methods for Behavioral and Social Science	
33-121	Physics I for Science Students [2]	12
or 33-141	Physics I for Engineering Students	
15-110	Principles of Computing	10-12
or 15-112	Fundamentals of Programming and Computer Science	
99-101	Computing @ Carnegie Mellon	3
Total Science units		**63-65**

[2] MCS students must also complete 33-122 Physics II for Biological Sciences & Chemistry Students.

Chemistry		Units
09-105	Introduction to Modern Chemistry I	10
09-106	Modern Chemistry II	10
09-217	Organic Chemistry I	9
09-218	Organic Chemistry II	9
09-207	Techniques in Quantitative Analysis	9
09-208	Techniques for Organic Synthesis and Analysis	9
Total Chemistry units		**56**

Psychology Courses		Units
85-102	Introduction to Psychology	9
85-219	Foundations of Brain and Behavior	9
85-2xx	Survey Psychology Courses [*]	18
85-310	Research Methods in Cognitive Psychology	9
or 85-314	Cognitive Neuroscience Research Methods	
or 85-320	Research Methods in Developmental Psychology	
or 85-330	Analytic Research Methods	
or 85-340	Research Methods in Social Psychology	
85-3xx	Advanced Psychology Electives	18
Total Psychology units		**63**

[*] Excluding 85-261 Psychopathology

Additional Advanced Elective		9 units
(Choose one of the following courses)		
85-3xx	Advanced Psychology Elective	9
or		
03-3xx	Advanced Biology Elective	9

Additional Laboratory or Research Methods		9-12 units
(Choose one of the following courses)		
03-344	Experimental Biochemistry	12
03-345	Experimental Cell and Developmental Biology	12
03-346	Experimental Neuroscience	12
85-310	Research Methods in Cognitive Psychology	9
85-314	Cognitive Neuroscience Research Methods	9
85-320	Research Methods in Developmental Psychology	9
85-330	Analytic Research Methods	9
85-340	Research Methods in Social Psychology	9

Elective Units	Units
Free Electives	33-36
MCS Nontechnical Breadth or DC General Education requirements	36-48
Total Elective units	**69-84**

Minimum number of units required for degree: 360

Bachelor of Science in Music and Technology

The Bachelor of Science in Music and Technology is offered jointly by the School of Music, the School of Computer Science, and the College of Engineering.

This program consists of a set of courses that span both music and technology, as well as a capstone composition/design/performance project. Courses in all three areas of study are stipulated in the music and technology undergraduate curriculum and provide for students coming from any of the three areas. In other words, regardless of a student's entry point — an interest in computer science, electrical engineering, or music — the coursework prescribed will allow the student to gain the requisite knowledge and experience in all three areas. Students will work closely with advisors and will be guided in both course selection and capstone projects.

Curriculum

Minimum units required for B.S. in Music and Technology 380

General Requirements 85 units

Seminar

57-570	Music and Technology Seminar (8 semesters for a total of 8 units)	1

University

99-101	Computing @ Carnegie Mellon	3
76-101	Interpretation and Argument	9
xx-xxx	Global, Cultural, and Diverse Perspectives Course	9

Humanities

xx-xxx	Cognition, Choice and Behavior course	9
xx-xxx	English, History, Modern Languages, Philosophy, or Psychology course	9

Mathematics

21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10

Science

33-114	Physics of Musical Sound	9
33-141	Physics I for Engineering Students	12

Electives 33 or 37 units

Music Core 81 units

57-152	Harmony I	9
57-153	Harmony II	9
57-408	Form and Analysis	6
57-151	Counterpoint in Theory and Application	6
57-258	20th-21st Century Techniques	6
57-257	Orchestration I	6
57-189	Introduction to Repertoire and Listening for Musicians	3
57-190	Repertoire and Listening for Musicians I	3
57-289	Repertoire and Listening for Musicians II	3
57-290	Repertoire and Listening for Musicians III	3
57-181	Solfege I	3
57-182	Solfege II	3
57-183	Solfege III	3
57-184	Solfege IV	3
57-161	Eurhythmics I	3
57-162	Eurhythmics II	3
57-173	Survey of Western Music History	9

Music and Technology Core 121 units

15-112	Fundamentals of Programming and Computer Science	12
15-122	Principles of Imperative Computation	12
15-322	Introduction to Computer Music	9
18-100	Introduction to Electrical and Computer Engineering	12
18-202	Mathematical Foundations of Electrical Engineering	12
18-290	Signals and Systems	12
57-101	Introduction to Music Technology	6
57-347	Electronic and Computer Music	6
57-337	Sound Recording	6
57-338	Sound Editing and Mastering	6
57-438	Multitrack Recording	9
57-571	Music and Technology Project	12
57-572	Music and Technology Project	12

Concentration

Students complete either the Music Concentration or the Technical Concentration:

Music Concentration		**60 units**
57-5xx	Studio (4 semesters)	36
57-4xx	Major Ensemble (4 semesters)	24

Technical Concentration		**58 or 56 units**
21-127	Concepts of Mathematics	12
15/18-213	Introduction to Computer Systems	12

AND EITHER:

18-220	Electronic Devices and Analog Circuits	12
18-240	Structure and Design of Digital Systems	12
15-2xx/18-3xx or above	Electives in ECE or CS	12

OR:

15-210	Parallel and Sequential Data Structures and Algorithms	12
15-323	Computer Music Systems and Information Processing	9
15-2xx/18-3xx or above	Electives in ECE or CS	12

Bachelor of Science in Neuroscience

Veronica Hinman, *Department Head, Biological Sciences*

Michael Tarr, *Department Head, Psychology*

www.cmu.edu/ni (https://www.cmu.edu/ni/)

Neuroscience is an interdisciplinary field in which scientists from many backgrounds apply the tools of biology, cognitive science, psychology, chemistry, mathematics, statistics, computer science, and engineering to develop a comprehensive understanding of brain function at the level of molecules, neurons, brain circuits, cognitive brain modules, and behavior. Research in neuroscience across these disciplines has grown substantially in the past two decades, and a solid understanding of the physiological basis of many aspects of brain function both in health and disease has come along with this growth in research. Along with this comes an increasing need for students to begin careers in neuroscience and to be prepared to work on the problems in neuroscience and to bring new answers to the public and to patients. In order to be successful in developing new treatments and answering outstanding questions in the field, neuroscientists need to be conversant in many different levels of inquiry from neurobiology to cognitive neuroscience to computational neuroscience.

The Dietrich College of Humanities & Social Sciences and the Mellon College of Science have joined forces to establish an exciting interdisciplinary program leading to a Bachelor of Science in Neuroscience. The goal of this degree program is to provide an intensive interdisciplinary education to enable outstanding students to become leaders in identifying and solving tomorrow's Neuroscience problems using a variety of methods. The program's interdisciplinary curriculum is designed for students to gain a fundamental understanding of brain function on many different levels and to begin to specialize within the broad field of Neuroscience. Students in Mellon College of Science or Dietrich College may have a primary major in Neuroscience in any of the three concentrations. Students from other colleges may have a

second major in Neuroscience in any of the three concentrations, subject to double-counting restrictions.

A degree in neuroscience provides excellent preparation for medical school or other graduate programs in the health professions. These students are aided by the Carnegie Mellon Health Professions Program (HPP), an advisory and resource service for all Carnegie Mellon students who are considering careers in the health care field. (See the HPP (http://coursecatalog.web.cmu.edu/aboutcmu/undergraduateoptions/#healthprofessionsprogram) section in this catalog or www.cmu.edu/hpp (http://www.cmu.edu/hpp/) for more information.)

Students wishing to pursue the Neuroscience major through Dietrich College should contact Dr. Lori Holt (loriholt@cmu.edu). Students wishing to pursue the Neuroscience major through the Mellon College of Science should contact the Biological Sciences Undergraduate Programs Office (bio-ungrad@andrew.cmu.edu). Students wishing to pursue an additional major in either the Neurobiology or Computational Neuroscience concentrations should contact the Biological Sciences Undergraduate Programs Office (bio-ungrad@andrew.cmu.edu). Students wishing to pursue an additional major in the Cognitive Neuroscience concentration should contact Dr. Lori Holt (loriholt@cmu.edu).

Students who pursue this major will:

- Gain a broad understanding of Neuroscience at many different levels of analysis, including: cellular biology of the brain, brain systems, cognitive brain function, and computational brain modeling
- Gain an understanding of the sciences underlying Neuroscience, including: Biology, Chemistry, Computer Science, Cognition and Psychology, and other emerging areas
- Develop a comprehensive understanding of brain function in health and disease
- Be familiar with neuroanatomy & neurophysiology and their implications for nervous system function
- Be prepared for advanced study in neurobiology, cognitive neuroscience, and/or neural computation
- Be able to collaborate with Neuroscientists across a wide range of systems and levels of analysis
- Prepare for careers in Neuroscience related companies, Neuroscience research, and/or medicine
- Be prepared for specialization within subfields of Neuroscience given their concentration selection

Requirements for a B.S. in Neuroscience

All students must complete the following:

1. General Science Requirements (see section A)
2. Core Neuroscience Courses (see section B)
3. Requirements for one concentration (see sections C, D, or E)*
4. 18 additional relevant course units in their home concentration or other neuroscience areas (some examples listed in sections C, D, E, & F). At least 9 of these units must be at the 300-level or above.
5. Their home college's General Education requirements
6. Free elective units to come to a total of 360 total course units

* **Double-counting restrictions and additional majors & minors**

- Students may not major in two concentrations.
- Students using Neuroscience as an additional major or who have an additional major or minor to Neuroscience may only double-count at most 3 courses between this an their other major or minor (this restriction does not apply to prerequisites, General Education Requirements, or the General Science Requirements – section A).
- Other majors and minors may have more stringent double-counting restrictions, please consult with your neuroscience advisors and with the advising staff for the relevant host department for the other majors/minors.

A. General Science Requirements

		Units
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
03-121	Modern Biology	9
or 03-151	Honors Modern Biology	
03-201	Undergraduate Colloquium for Sophomores	1
03-220	Genetics	9
or 03-221	Genomes, Evolution, and Disease: Introduction to Quantitative Genetic Analysis	
09-105	Introduction to Modern Chemistry I	10
09-106	Modern Chemistry II	10
09-207	Techniques in Quantitative Analysis [1]	9-12
or 09-221	Laboratory I: Introduction to Chemical Analysis	
or 03-124	Modern Biology Laboratory	
09-217	Organic Chemistry I [1]	9
or 33-122	Physics II for Biological Sciences & Chemistry Students	
33-121	Physics I for Science Students	12
15-110	Principles of Computing [2]	10-12
or 15-112	Fundamentals of Programming and Computer Science	
36-200	Reasoning with Data [2]	9
or 36-218	Probability Theory for Computer Scientists	
or 36-219	Probability Theory and Random Processes	
or 36-225	Introduction to Probability Theory	
99-101	Computing @ Carnegie Mellon	3
		111-116

[1] Neurobiology concentration students are required to complete 09-217 & 09-207 or 09-221.

[2] Computational Neuroscience concentration students are required to complete 21-122, 15-112, & 36-218 or 36-219

B. Core Neuroscience Courses

		Units
85-219	Foundations of Brain and Behavior	9
or 03-161	Molecules to Mind	
85-211	Cognitive Psychology	9
or 85-213	Human Information Processing and Artificial Intelligence	
03-362	Cellular Neuroscience	9
03-363	Systems Neuroscience	9
15-386	Neural Computation [3]	9
or 85-419	Introduction to Parallel Distributed Processing	
or 02-319/03-360	Genomics and Epigenetics of the Brain	
or 86-375	Computational Perception	
or 85-435	Biologically Intelligent Exploration	
		45

[3] Computational Neuroscience concentration students are required to complete 15-386.

C. Neurobiology Concentration

Didactic Core: Students must complete all of the following*		Units
03-231	Honors Biochemistry	9
03-320	Cell Biology	9
		18

* Neurobiology concentration students must complete 09-217 & 09-207 or 09-221 in their General Science Requirements (section A, above)

Required laboratory, data analysis, & methodological courses		Units
03-343	Experimental Techniques in Molecular Biology	12
03-346	Experimental Neuroscience	12
or 03-345	Experimental Cell and Developmental Biology	
		24

Electives in Neurobiology (minimum of 18 additional units, at least 9 units at 300-level or above)**		Units
03-133	Neurobiology of Disease	9
02-250	Introduction to Computational Biology	12
03-350	Developmental Biology	9
03-365	Neural Correlates of Learning and Memory	9
03-366	Neuropharmacology: Drugs, Brain and Behavior	9
03-439	Introduction to Biophysics	10
03-442	Molecular Biology	9
09-218	Organic Chemistry II	9

09-208	Techniques for Organic Synthesis and Analysis	9
or 09-222	Laboratory II: Organic Synthesis and Analysis	
42-202	Physiology	9
42-203	Biomedical Engineering Laboratory NOTE: VERY Limited Seating Available for 42-203	9

** At least 9 of these units must be 300-level or above

D. Cognitive Neuroscience Concentration

Didactic Core. Students must complete all of the following		Units
85-102	Introduction to Psychology	9
36-309	Experimental Design for Behavioral & Social Sciences	9
		18

Required laboratory, data analysis, & methodological courses		Units
85-310	Research Methods in Cognitive Psychology	9
85-314	Cognitive Neuroscience Research Methods	9
		18

Electives in Cognitive Neuroscience (minimum of 27 additional hours)**		Units
85-221	Principles of Child Development	9
85-241	Social Psychology	9
85-261	Psychopathology	9
85-356	Expertise: The cognitive (neuro)science of mastering almost any skill	9
85-370	Perception	9
85-406	Autism: Psychological and Neuroscience Perspectives	9
85-408	Visual Cognition	9
85-412	Cognitive Modeling	9
85-414	Cognitive Neuropsychology	9
85-419	Introduction to Parallel Distributed Processing *	9
85-424	Hemispheric Specialization: Why, How and What?	9
85-426	Learning in Humans and Machines	9
85-429	Cognitive Brain Imaging	9
85-442	Health Psychology	9
85-501	Readings in Developmental psychology	9

* If not used as a core course
** At least 18 of these units must be 300-level or above

E. Computational Neuroscience Concentration

Strong candidates for the Computational Neuroscience Concentration will have earned a B average in 21-127, 21-241, 15-112, and 15-122. We strongly recommend meeting with your advisor to discuss interest in this major and for help planning appropriate schedules to support student success.

Didactic Core. Students must complete all of the following*		Units
21-127	Concepts of Mathematics	12
15-122	Principles of Imperative Computation	12
or 15-150	Principles of Functional Programming	
21-241	Matrices and Linear Transformations	10
or 21-240	Matrix Algebra with Applications	
		34

* Computational Neuroscience concentration students must complete 21-122, 15-112, and 36-218 or 36-219 in their General Science Requirements (section A, above) and 15-386 in their Core Neuroscience Courses (section B, above). Students must complete a minimum of 60 units in this concentration. Students should select their required laboratory and elective courses to complete a minimum of 31 units (Four 9 unit courses or a lesser number of 9 and 12 unit courses could be combined to complete this requirement).

Required laboratory, data analysis, and methodological courses (18-24 total units)		Units
42/86-631	Neural Data Analysis	12
42-632	Neural Signal Processing	12
15-494	Cognitive Robotics: The Future of Robot Toys	12
15-883	Computational Models of Neural Systems	12
85-419	Introduction to Parallel Distributed Processing	9
85-435	Biologically Intelligent Exploration	9

Electives in Computational Neuroscience (minimum of 9 units)		Units
03-360/02-319	Genomics and Epigenetics of the Brain	9
02-512	Computational Methods for Biological Modeling and Simulation	9
10-301	Introduction to Machine Learning (Undergrad)	12
or 10-315	Introduction to Machine Learning (SCS Majors)	
or 10-601	Introduction to Machine Learning (Master's)	
15-387	Computational Perception	9
15-451	Algorithm Design and Analysis	12
15-453	Formal Languages, Automata, and Computability	9
15-494	Cognitive Robotics: The Future of Robot Toys	12
15-883	Computational Models of Neural Systems	12
16-299	Introduction to Feedback Control Systems	12
16-311	Introduction to Robotics	12
21-228	Discrete Mathematics	9
or 15-251	Great Ideas in Theoretical Computer Science	
21-259	Calculus in Three Dimensions	10
21-341	Linear Algebra	9
36-226	Introduction to Statistical Inference	9
36-350	Statistical Computing	9
36-401	Modern Regression	9
36-462	Special Topics: Methods of Statistical Learning	9
42/86-631	Neural Data Analysis	12
42-632	Neural Signal Processing	12
42-688	Introduction to Neural Engineering	12

F. Additional Neuroscience Electives

Students are required to take a minimum of 18 additional relevant course units beyond those required for the concentration. These electives can be additional coursework from their home concentration or other neuroscience areas. Some examples are listed in sections C, D, & E above as well as in the list below. At least 9 of these additional 18 units must be at the 300-level or above.

NOTE: this list is not restrictive. Concentration advisors can approve additional elective courses that contribute to the student's neuroscience education, subject to additional approval by the major steering committee.

Examples of Additional Electives relevant to major*		
33-122	Physics II for Biological Sciences & Chemistry Students unless used for Science Core (section A)	9
76-385	Introduction to Discourse Analysis	9
80-210	Logic and Proofs	9
80-211	Logic and Mathematical Inquiry	9
80-220	Philosophy of Science	9
80-254	Analytic Philosophy	9
80-270	Problems of Mind and Body: Meaning and Doing	9
80-280	Linguistic Analysis	9
88-355	Social Brains: Neural Bases of Social Perception and Cognition	9

* Up to 9 units of applicable undergraduate research course work (e.g. 03-445 or 85-507/85-508) can count as a neuroscience elective (not towards a concentration). A maximum of 27 additional units can be counted as a free electives.

Free Electives (depending on concentration & college)	**51-61**
TOTAL hours to degree	**360**