Intercollege 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 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
- Science and Humanities Scholars Program (B.A./B.S.)

Intercollege Minors

- Minor in Computational Finance
- Minor in Game Design (IDeATe)
- Minor in Health Care Policy and Management

BXA Intercollege Degree Programs

The BXA Intercollege Degree Programs enable students the freedom to individualize their educational experience by promoting integration, balance and innovation. There are three degree programs from which to choose:

- Bachelor of Humanities and Arts
- Bachelor of Science and Arts
- Bachelor of Computer Science and Arts

For detailed information on the BXA Intercollege Degree Programs, go to BXA Intercollege Degree Programs (http://coursecatalog.web.cmu.edu/servicesandoptions/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 an 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 other 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. Students apply for admission to the B.S. program in Computational Finance in the second semester of the sophomore year. Later application is also possible.

The Bachelor of Science in Computational Finance is an Intercollegiate Program. Students who pursue Computational Finance as their primary major may elect to have 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 the same in either case, with one minor exception outlined below. The general education requirements for the degree depend on the student's home college. MCS students must complete the same Humanities, Social Sciences, and Fine Arts requirements as other MCS students. In addition, MCS students are required to take two science courses, one fewer than other MCS majors. Tepper students must complete the Breadth Requirements of the Undergraduate Business Administration Program. Additionally, they must take several courses from the Functional Business Core of that program.

Majors in Computational Finance can tailor their degree program by selecting Depth Electives aligned with their interests and ambitions. MCS students are required to take three depth electives. Tepper students must take two depth electives and 70-391 Finance (MCS students may select 70-391 as one of their three depth electives).

MCS Science Requirements

Students intending to apply to the B.S. program in Computational Finance should take two semesters of calculus, 21-120 Differential and Integral Calculus and 21-122 Integration and Approximation, and 15-110 Principles of Computing.

In addition, in the freshman year students should complete two of the following three courses:

03-121	Modern Biology	9
09-105	Introduction to Modern Chemistry I	10
33-111	Physics I for Science Students	12

MCS Humanities, Social Sciences & Fine Arts Requirements

Candidates for the B. S. in Computational Finance must complete 72 units offered by Dietrich College of Humanities and Social Science and/or the College of Fine Arts. Of these 72 units, 36 are specified by the detailed curriculum in below. These are:

76-101	Interpretation and Argument	9
73-102	Principles of Microeconomics	9
73-103	Principles of Macroeconomics	9
73-240	Intermediate Macroeconomics	9

Two more nine unit courses must be in specific categories: One in Category 1: Cognition, Choice and Behavior, and one in Category 3: Cultural Analysis. The remaining 18 units may be filled by courses from any of the departments in DC, CFA or Tepper, subject to the list of exclusions and additions maintained by MCS.

Tepper Functional Business Core

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 , 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:

70-100	Global Business	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

Tepper Breadth Requirements

Candidates for the B.S. in Computational Finance must complete the breadth requirements outlined in the section describing the Undergraduate Business Administration Program.

Depth Electives

The detailed curricula below include two or three depth electives. The courses listed below may be taken as depth electives, but it is not an exhaustive list. The Director of Undergraduate Computational Finance may approve other finance related courses as depth electives.

21-355	Principles of Real Analysis I	9
21-365	Projects in Applied Mathematics	9
21-372	Partial Differential Equations and Fourier Analysis	9
36-401	Modern Regression	9
36-402	Advanced Methods for Data Analysis	9
70-391	Finance	9
70-398	International Finance	9
70-492	Investment Analysis	9
70-495	Corporate Finance	9
70-497	Derivative Securities	9
73-372	International Money and Finance	9

MCS Detailed Curriculum

What follows is the detailed curriculum for the degree Bachelor of Science in Computational Finance in the Mellon College of Science. The courses listed are required. The semesters in which the courses are to be taken are suggested.

Freshman Year

Fall		Units
15-110	Principles of Computing	10
21-120	Differential and Integral Calculus	10
76-101	Interpretation and Argument	9
99-101	Computing @ Carnegie Mellon	3
xx-xxx	Science Requirement	9-12
		41-44

Spring		Units
15-112	Fundamentals of Programming and Computer Science	12
21-122	Integration and Approximation	10
70-122	Introduction to Accounting	9
xx-xxx	Science Requirement (9-12 units)	12
xx-xxx	Elective	9
		52

Sophomore Year

Fall		Units
21-127	Concepts of Mathematics	10
21-259	Calculus in Three Dimensions	9
21-260	Differential Equations	9
73-102	Principles of Microeconomics	9
xx-xxx	Humanities, Social Science or Fine Arts Elective	9
		46

Spring		Units
21-241	Matrices and Linear Transformations	10
21-270	Introduction to Mathematical Finance	9
21-369	Numerical Methods	9
73-103	Principles of Macroeconomics	9
xx-xxx	Elective	9
		46

Junior Year

Fall		Units
15-122	Principles of Imperative Computation	10
21-325	Probability	9
21-370	Discrete Time Finance	9
73-240	Intermediate Macroeconomics	9
xx-xxx	Elective	9
		46

Spring		Units
21-420	Continuous-Time Finance	9
36-226	Introduction to Statistical Inference	9
xx-xxx	Depth Elective	9
xx-xxx	Humanities, Social Science or Fine Arts Elective	9
xx-xxx	Elective	
		36

Senior Year

Fall		Units
36-401	Modern Regression	9
94-700	Organizational Design & Implementation	6
94-702	Professional Writing	6
or 94-701	Business English	
xx-xxx	Depth Elective	9
xx-xxx	Humanities, Social Science or Fine Arts	9
xx-xxx	Elective	9
		48

Spring		Units
90-718	Strategic Presentation Skills	6
45-925	Studies in Financial Engineering	6
xx-xxx	Depth Elective	9
xx-xxx	Humanities, Social Science or Fine Arts Elective	9
xx-xxx	Elective	9
xx-xxx	Elective	9
		48

Tepper Detailed Curriculum

What follows is the detailed curriculum for the degree Bachelor of Science in Computational Finance in the Tepper School of Business. The courses listed are required. The semesters in which the courses are to be taken are suggested.

Freshman Year

Fall		Units
15-110	Principles of Computing	10
21-120	Differential and Integral Calculus	10
or 21-122	Integration and Approximation	
70-100	Global Business	9
73-102	Principles of Microeconomics	9
76-101	Interpretation and Argument	9
99-101	Computing @ Carnegie Mellon	3
		50

Spring		Units
15-112	Fundamentals of Programming and Computer Science	12
21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10
73-103	Principles of Macroeconomics	9
xx-xxx	Breadth Course	9
xx-xxx	Breadth Course	9
		59

Sophomore Year

Fall		Units
21-259	Calculus in Three Dimensions	9
21-260	Differential Equations	9
21-325	Probability	9
70-122	Introduction to Accounting	9
73-240	Intermediate Macroeconomics	9
		45

Spring		Units
21-241	Matrices and Linear Transformations	10
21-270	Introduction to Mathematical Finance	9
36-226	Introduction to Statistical Inference	9
70-311	Organizational Behavior	9
70-381	Marketing I	9
		46

Junior Year

Fall		Units
15-122	Principles of Imperative Computation	10
21-370	Discrete Time Finance	9
70-391	Finance	9
xx-xxx	Breadth Course	9
xx-xxx	Elective	9
		46

Spring		Units
21-369	Numerical Methods	9
21-420	Continuous-Time Finance	9
70-371	Operations Management	9
xx-xxx	Breadth Course	
xx-xxx	Breadth Course	9
		36

Senior Year

Fall		Units
36-401	Modern Regression	9
70-332	Business, Society and Ethics	9

70-401	Management Game	12
xx-xxx	Depth Elective	9
xx-xxx	Breadth Course	9
		48

Spring		Units
45-925	Studies in Financial Engineering	6
90-718	Strategic Presentation Skills	6
94-702	Professional Writing	6
or 94-701	Business English	
xx-xxx	Depth Elective	9
xx-xxx	Breadth Course	9
xx-xxx	Elective	9
		45

Minor in Computational Finance

Students do not need to apply for the minor in Computational Finance, however in order to declare the minor in Computational Finance, a student must satisfy one of the following two 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.

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.

21-241	Matrices and Linear Transformations	9-10
or 21-242	Matrix Theory	
or 21-341	Linear Algebra	
21-259	Calculus in Three Dimensions	9
or 21-256	Multivariate Analysis	
21-260	Differential Equations	9
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 a prerequisite for 21-341 and 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 .

Game Design Minor – IDeATe

The Game Design minor is offered by the Entertainment Technology Center as part of the Integrative Design, Arts and Technology (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 state-of-the-art 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 eight interrelated concentration 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, Learning Media, Sound Design, Innovation and Entrepreneurship, Intelligent Environments, and Physical Computing. For more information about the IDeATe network, please visit http://coursecatalog.web.cmu.edu/servicesandoptions/undergraduateoptions/#ideate

In the Game Design minor, students are able to enhance their knowledge of key component areas of games such as dramatic narrative and character development, programming and engine development, game assessment and redesign. They will have the opportunity to create games for varied platforms from mobile devices to home entertainment systems and theme parks.

Curriculum

Required Courses

One Portal Course		
15-104	Introduction to Computing for Creative Practice *	10
62-150	IDeATe: Introduction to Media Synthesis and Analysis	10

* DC, CFA, and TSB students may take 15-112 Fundamentals of Programming and Computer Science as a substitute for 15-104.

Four Collaborative or Supportive Courses		
05-418	Design Educational Games	12
15-466	Computer Game Programming	12
53-230	Programming for Game Designers	12
53-371	Role Playing Games Writing Workshop	12
53-409	Game Design	12
53-451	Research Issues in Game Development	10
53-471	Game Design, Prototyping and Production	12
60-419	Advanced ETB: Experimental Game Design	10
60-333	Character Rigging for Production	10

Electives

Students may take a collaborative or supportive course from one of the other IDeATe areas as one of their four collaborative or supportive courses toward the Game Design minor.

Double-Counting Restriction

Students may double-count two of their Game Design 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 (42 Unit minimum)

Seven courses (a minimum of 60 units) are required to complete this minor. Entry into the minor requires completion of 88-220 Policy Analysis I or the equivalent by approval.

Required Courses

Students are required to take the following courses.		
79-330	Medicine and Society	9
94-705	Health Economics	12
90-836	Health Systems	6
90-861	Health Policy	6

Elective Courses **24 units**

Complete a minimum of 24 units.

Heinz College Courses		
90-721	Healthcare Management	6
90-818	Health Care Quality & Performance Improvement	6
90-831	Advanced Financial Management of Health Care	6
94-706	Healthcare Information Systems	12
90-832	Health Law	6

Humanities and Social Sciences Courses (9 units each)		
76-494	Healthcare Communications	9
79-318	Sustainable Social Change: History and Practice	9
80-245	Medical Ethics	9
80-247	Ethics and Global Economics	9
85-241	Social Psychology	9
85-442	Health Psychology	9
85-446	Psychology of Gender	9

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

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 (SCS), and the Carnegie Institute of Technology (CIT).

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	Sound and Music Computing Seminar (8 semesters for a total of 8 units)	1

University

99-10x	Computing @ Carnegie Mellon	3
76-101	Interpretation and Argument	9
79-104	Global Histories	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
33-106	Physics I for Engineering Students	12

Electives 33 units

Music Core 87 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-xxx	Music Support Course	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 120 units

15-112	Fundamentals of Programming and Computer Science	12
15-122	Principles of Imperative Computation	10
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		**57 or 55 units**
21-127	Concepts of Mathematics	10
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 Electives in ECE or CS or above		12

OR:

15-128	Freshman Immigration Course	1
15-210	Parallel and Sequential Data Structures and Algorithms	12
15-323	Computer Music Systems and Information Processing	9
15-2xx/18-3xx Electives in ECE or CS or above		12

Bachelor of Science in Neuroscience

Aaron P. Mitchell, Department Head, Biological Sciences

Michael Tarr, Department Head, Psychology

www.cmu.edu/neuro

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, Dietrich College, or Science and Humanities Scholars Program 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/servicesandoptions/undergraduateoptions/#healthprofessionsprogram) section in this catalog or 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 Dr. Becki Campanaro (bcampana@andrew.cmu.edu). Students wishing to pursue an additional major in either the Neurobiology or Computational Neuroscience concentrations should contact Dr. Becki Campanaro (bcampana@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
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	
or 02-201	Programming for Scientists	
36-201	Statistical Reasoning and Practice [2]	9
or 36-217	Probability Theory and Random Processes	
or 36-247	Statistics for Lab Sciences	
or 36-225	Introduction to Probability Theory	
		108-113

[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, & 36-217

B. Core Neuroscience Courses

		Units
85-219	Biological Foundations of Behavior	9
or 03-161	Molecules to Mind	
85-211	Cognitive Psychology	9
or 85-213	Human Information Processing and Artifical 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	Genomics and Epigenetics of the Brain	
or 86-375	Computational Perception	
		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
03-231/232	Biochemistry I	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)**		Units
03-133	Neurobiology of Disease	9
03-250	Introduction to Computational Biology	12
03-251	Introduction to Computational Molecular Biology	6
03-252	Introduction to Computational Cell Biology	6
03-350	Developmental Biology	9
03-364	Developmental Neuroscience	9
03-365	Neural Correlates of Learning and Memory	9
03-366	Biochemistry of the Brain	9
03-439	Introduction to Biophysics	9
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 and 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	Abnormal Psychology	9
85-356	Music and Mind: The Cognitive Neuroscience of Sound	9
85-370	Perception	9
85-390	Human Memory	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	Stress, Coping and Well-Being	9

* If not used as a core course

** At least 18 of these hours must be 300 level or above

E. Computational Neuroscience Concentration

Didactic Core. Students must complete all of the following*		Units
21-127	Concepts of Mathematics	10
15-122	Principles of Imperative Computation	10
or 15-150	Principles of Functional Programming	
21-241	Matrices and Linear Transformations	10
or 21-240	Matrix Algebra with Applications	
		30

* Computational Neuroscience concentration students must complete 21-122, 15-112, and 36-217 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
42-631	Neural Data Analysis	9
or 86-631	Neural Data Analysis	
42-632	Neural Signal Processing	12
15-494	Cognitive Robotics: The Future of Robot Toys	12
15-883	Computational Models of Neural Systems	12

Electives in Computational Neuroscience (minimum of 9 units)		Units
03-512	Computational Methods for Biological Modeling and Simulation	9
or 02-512	Computational Methods for Biological Modeling and Simulation	
10-601	Introduction to Machine Learning (Master's)	12
15-381	Artificial Intelligence: Representation and Problem Solving	9
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	9
21-272	Introduction to Partial Differential Equations	9
21-341	Linear Algebra	9
36-208	Regression Analysis	9
36-226	Introduction to Statistical Inference	9
36-350	Statistical Computing	9
36-401	Modern Regression	9
36-462	Special Topics: Data Mining	9
42-631	Neural Data Analysis	9
or 86-631	Neural Data Analysis	
42-632	Neural Signal Processing	12

F. Additional Neuroscience Electives

Students are required to take a minimum of 18 additional relevant course units in 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 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	Philosophy of Mind	9
80-280	Linguistic Analysis	9
80-314	Logic and Artificial Intelligence	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**

B.S. in Psychology & Biological Sciences

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. Students in the joint Science and Humanities Scholars (SHS) program can complete the SHS educational core and choose either departmental order for their diploma.

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/dietrichcollegeofhumanitiesandsocialsciences/

#hampssgeneraleducationprogram160) and MCS (http://coursecatalog.web.cmu.edu/melloncollegeofscience) are found on their respective Catalog pages.

Degree Requirements:

Biological Sciences		Units
03-121	Modern Biology	9
or 03-151	Honors Modern Biology	
03-220	Genetics	9
03-231/232	Biochemistry I	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		77

[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
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
36-247	Statistics for Lab Sciences	9
or 36-201	Statistical Reasoning and Practice	
36-309	Experimental Design for Behavioral and Social Sciences	9
33-121	Physics I for Science Students [2]	12
15-110	Principles of Computing	10-12
or 15-112	Fundamentals of Programming and Computer Science	
or 02-201	Programming for Scientists	
99-10x	Computing at 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
or 09-219	Modern Organic Chemistry	
09-218	Organic Chemistry II	9
or 09-220	Modern Organic Chemistry II	
09-207	Techniques in Quantitative Analysis	9-12
or 09-221	Laboratory I: Introduction to Chemical Analysis	
09-208	Techniques for Organic Synthesis and Analysis	9-12
or 09-222	Laboratory II: Organic Synthesis and Analysis	
Total Chemistry units		56-62

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

[*] Excluding 85-261 Abnormal Psychology

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
85-310	Research Methods in Cognitive Psychology	9
85-314	Cognitive Neuroscience Research Methods	9
85-320	Research Methods in Developmental Psychology	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

Science and Humanities Scholars Program

Sponsored by the Dietrich College of Humanities and Social Sciences and by the Mellon College of Science
Dr. William Alba, Director and Assistant Dean
Office: Doherty Hall, Room 2201
http://www.cmu.edu/shs

The Science and Humanities Scholars (SHS) Program supports undergraduate students seeking to build their education upon a solid academic foundation in the humanities, social sciences, natural sciences, and mathematics. Students in the program, whether formally enrolled in the Mellon College of Science (MCS) or the Dietrich College of Humanities and Social Sciences (DC), can readily access the resources of both colleges. The SHS General Education curriculum enables students to prepare for any field of study in two colleges while exploring the entire university.

Science and Humanities Scholars in their first year may choose to live in a Stever House residential cluster that promotes the integration of academic and social interests. The program additionally provides students with interdisciplinary and multidisciplinary courses and activities.

Before a student declares a major, the Program Director serves as the student's primary academic advisor, complementing the range of other advising opportunities available around the university. After a student declares a major, the Director continues to provide supplementary advising for the student, especially on matters of General Education.

Entering first-year students who apply to DC or MCS with outstanding credentials may receive an invitation to the SHS Program. Invited students should carefully consider whether this academic program matches their own scholarly interests. Students enrolled in either college may also request to transfer into the Science and Humanities Scholars Program after completing at least one semester at the university.

Science and Humanities Scholars General Education Program

The requirements in the SHS General Education Program are designed to expose students to a variety of subjects and methodologies, in order to enable them to become better citizens of the world and more complete scholars. The curriculum permits flexibility and independence in selecting courses to fulfill these General Education requirements; students in the Program may petition the Director to take alternate courses in addition to the ones listed here.

Mathematical Sciences (20 units)

		Units
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	

Statistical Reasoning (9 units)

Students may select one of the following courses **or** any other Statistics course at the 200- level or higher.

36-200	Reasoning with Data	9
36-201	Statistical Reasoning and Practice	9
36-202	Methods for Statistics and Data Science	9
21-325	Probability	9
36-217	Probability Theory and Random Processes	9
36-225	Introduction to Probability Theory	9
36-247	Statistics for Lab Sciences	9

Writing/Expression (9 units)

Language is a tool used to communicate, as well as a way to organize thinking. This university-wide requirement, to be completed in the first year, focuses on the social nature of language and the ways in which writing constitutes thinking.

76-101	Interpretation and Argument	9
or 76-102	Advanced First Year Writing: Special Topics	

World Cultures (9 units)

This requirement seeks to enable students to recognize how cultures have shaped and continue to shape the human experience, as well as analyze material that provide clues as to how these cultures operate.

79-104	Global Histories	9

Freshman Seminar (6-9 units)

Students may select seminars offered by the SHS Program, Dietrich College, and the Mellon College of Science, from a list of courses provided every semester. Past and present SHS seminars include:

99-241	Revolutions of Circularity	9
99-242	Meaning Across the Millennia	9
99-243	Light from the Enlightenment	
99-245	Energy: Science, Society and Communication	9

Computational Reasoning (9-12 units)

Students may select one of the following courses offered in Computer Science, Mathematical Sciences, Philosophy, or related fields.

21-127	Concepts of Mathematics	10
21-128	Mathematical Concepts and Proofs	12
80-210	Logic and Proofs	9
80-211	Logic and Mathematical Inquiry	9
80-212	Arguments and Logical Analysis	9
15-110	Principles of Computing	10
15-112	Fundamentals of Programming and Computer Science	12
15-104	Introduction to Computing for Creative Practice	10
15-121	Introduction to Data Structures	10
15-122	Principles of Imperative Computation	10
02-201	Programming for Scientists	10

Science Core (28 units)

Choose three of the following courses. Science majors with primary majors in the Mellon College of Science must complete at least two that are outside of their major department.

03-121	Modern Biology	9-10
or 03-151	Honors Modern Biology	
03-230	Intro to Mammalian Physiology	9
or 42-202	Physiology	
09-105	Introduction to Modern Chemistry I	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-106	Modern Chemistry II	10
33-121	Physics I for Science Students	12
or 33-151	Matter and Interactions I	
33-142	Physics II for Engineering and Physics Students	9-12
or 33-151	Matter and Interactions I	
or 33-122	Physics II for Biological Sciences & Chemistry Students	

Distribution Requirements (36 units)

Choose a minimum of four courses, 9 units per category, totaling at least 36 units. Below are examples of courses satisfying these categories. You are encouraged to identify other courses that could fulfill these requirements; see the SHS Director for prior approval.

Cognition, Choice, and Behavior

Courses in this category use model-based analysis to broaden an understanding of human thinking, choices, and behavior on an individual basis across a variety of settings. The following list includes examples from Philosophy, Psychology, and Social and Decision Sciences.

80-100	Introduction to Philosophy	9
80-130	Introduction to Ethics	9
80-150	Nature of Reason	9
80-180	Nature of Language	9
80-221	Philosophy of Social Science	9
80-230	Ethical Theory	9
80-241	Ethical Judgments in Professional Life	9
80-270	Philosophy of Mind	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	Abnormal Psychology	9
88-120	Reason, Passion and Cognition	9

Economic, Political, and Social Institutions

Courses in this category examine the ways in which institutions organize individual preferences and actions into collective outcomes using model-based reasoning. The following list includes examples primarily from Economics, History, and Social and Decision Sciences; similar courses in those and other departments may also fulfill this requirement.

36-303	Sampling, Survey and Society	9
70-332	Business, Society and Ethics	9
73-102	Principles of Microeconomics	9
73-103	Principles of Macroeconomics	9
73-230	Intermediate Microeconomics	9
79-266	Russian History: From Communism to Capitalism	9
79-318	Sustainable Social Change: History and Practice	9
79-331	Body Politics: Women and Health in America	9
79-350	Early Christianity	9
80-135	Introduction to Political Philosophy	9
80-135	Introduction to Political Philosophy	9
80-136	Social Structure, Public Policy & Ethics	9
80-341	Computers, Society and Ethics	9
84-104	Decision Processes in American Political Institutions	9

Creative Production and Reflection

Courses in this category encourage exploration of the artistic and intellectual creation of others while allowing for personal expression and reflection upon the creative process.

xx-xxx	Courses from the College of Fine Arts (Architecture 48-xxx, Design 51-xxx, Drama 54-xxx, Music 57-xxx, Art 60-xxx, CFA Interdisciplinary 62-xxx)	Var.
76-260	Survey of Forms: Fiction	9
76-262	Survey of Forms: Nonfiction	9
76-265	Survey of Forms: Poetry	9
76-269	Survey of Forms: Screenwriting	9
79-345	Roots of Rock & Roll	9
80-220	Philosophy of Science	9
82-1xx	Any Elementary Modern Language course	
82-2xx	Any Intermediate Modern Language course	
99-241	Revolutions of Circularity	9
99-242	Meaning Across the Millennia	9

Cultural Analysis

Courses in this category explore definitions of culture and the role culture plays in producing different actions and institutions, as well as the roles of institutions, systems, and human actions in shaping cultural contexts.

57-173	Survey of Western Music History	9
70-342	Managing Across Cultures	9
76-227	Comedy	9
76-232	Introduction to African American Literature	9
76-241	Introduction to Gender Studies	9
79-201	Introduction to Anthropology	9
79-240	Development of American Culture	9
79-207	Development of European Culture	9
79-241	African American History: Africa to the Civil War	9

79-242	African American History: Reconstruction to the Present	9
79-224	Mayan America	9
79-261	The Last Emperors: Chinese History and Society, 1600-1900	9
79-318	Sustainable Social Change: History and Practice	9
79-330	Medicine and Society	9
79-345	Roots of Rock & Roll	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	9
80-261	Empiricism and Rationalism	9
82-273	Introduction to Japanese Language and Culture	9
82-294	Topics in Russian Language and Culture	9
82-303	Introduction to French Culture	9
82-304	The Francophone World	9
82-333	Introduction to Chinese Language and Culture	Var.
82-342	Spain: Language and Culture	9
82-343	Latin America: Language and Culture	9
82-344	U.S. Latinos: Language and Culture	9
82-345	Introduction to Hispanic Literary and Cultural Studies	9
82-396	The Faust Legend at Home and Abroad	Var.
82-415	Topics in French and Francophone Studies	9
82-426	Topics in German Literature and Culture	9
82-451	Studies in Latin American Literature and Culture	9