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 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:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>03-121</td>
<td>Modern Biology</td>
<td>9</td>
</tr>
<tr>
<td>09-105</td>
<td>Introduction to Modern Chemistry I</td>
<td>10</td>
</tr>
<tr>
<td>33-111</td>
<td>Physics I for Science Students</td>
<td>12</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>76-101</td>
<td>Interpretation and Argument</td>
<td>9</td>
</tr>
<tr>
<td>73-102</td>
<td>Principles of Microeconomics</td>
<td>9</td>
</tr>
<tr>
<td>73-103</td>
<td>Principles of Macroeconomics</td>
<td>9</td>
</tr>
<tr>
<td>73-240</td>
<td>Intermediate Macroeconomics</td>
<td>9</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>70-100</td>
<td>Global Business</td>
<td>9</td>
</tr>
<tr>
<td>70-311</td>
<td>Organizational Behavior</td>
<td>9</td>
</tr>
<tr>
<td>70-332</td>
<td>Business, Society and Ethics</td>
<td>9</td>
</tr>
<tr>
<td>70-371</td>
<td>Operations Management</td>
<td>9</td>
</tr>
<tr>
<td>70-381</td>
<td>Marketing I</td>
<td>9</td>
</tr>
<tr>
<td>70-401</td>
<td>Management Game</td>
<td>12</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-355</td>
<td>Principles of Real Analysis I</td>
<td>9</td>
</tr>
<tr>
<td>21-365</td>
<td>Projects in Applied Mathematics</td>
<td>9</td>
</tr>
<tr>
<td>21-372</td>
<td>Partial Differential Equations and Fourier Analysis</td>
<td>9</td>
</tr>
<tr>
<td>36-401</td>
<td>Modern Regression</td>
<td>9</td>
</tr>
<tr>
<td>36-402</td>
<td>Advanced Methods for Data Analysis</td>
<td>9</td>
</tr>
<tr>
<td>70-391</td>
<td>Finance</td>
<td>9</td>
</tr>
<tr>
<td>70-398</td>
<td>International Finance</td>
<td>9</td>
</tr>
<tr>
<td>70-492</td>
<td>Investment Analysis</td>
<td>9</td>
</tr>
<tr>
<td>70-495</td>
<td>Corporate Finance</td>
<td>9</td>
</tr>
<tr>
<td>70-497</td>
<td>Derivative Securities</td>
<td>9</td>
</tr>
</tbody>
</table>
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
- 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
- Total 41-44

Spring
- 15-112 Fundamentals of Programming and Computer Science 12
- 21-122 Integration and Approximation 10
- 70-100 Global Business 9
- 73-102 Principles of Microeconomics 9
- xx-xxx Elective 9
- Total 52

Sophomore Year

Fall
- 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
- Total 46

Spring
- 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
- Total 46

Junior Year

Fall
- 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
- Total 46

Spring
- 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 9
- Total 36

Senior Year

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

Spring
- 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
- Total 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
- 15-110 Principles of Computing 10
- 21-120 Differential and Integral Calculus 10
- or 21-122 Integration and Approximation 10
- 70-100 Global Business 9
- 73-240 Intermediate Macroeconomics 9
- 45

Spring
- 15-112 Fundamentals of Programming and Computer Science 12
- 21-122 Integration and Approximation 10
- 21-260 Differential Equations 9
- 21-325 Probability 9
- 70-381 Marketing I 9
- 46

Sophomore Year

Fall
- 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
- 21-241 Matrices and Linear Transformations 10
- 21-270 Introduction to Mathematical Finance 9
- 36-226 Introduction to Statistical Inference 9
- 70-381 Marketing I 9
- 46

Junior Year

Fall
- 15-122 Principles of Imperative Computation 10
- 21-370 Discrete Time Finance 9
- 70-391 Finance 9
- 46

Spring
- 21-369 Numerical Methods 9
- 21-420 Continuous-Time Finance 9
- 70-371 Operations Management 9
- 46
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 Multivariable 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 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 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 minorin in Computational Finance are strongly encouraged to take one or two economics courses, 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.
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
57-256 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 Eurythmics I 3
57-162 Eurythmics 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 12
or above

OR:
15-128 Freshman Immigration Course 1
15-210 Parallel and Sequential Data Structures and Algorithms 12
Bachelor of Science in Neuroscience

Aarom P. Mitchell, Department Head, Biological Sciences
Michael Tarr, Department Head, Psychology
www.cm.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 advising 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 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

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-120</td>
<td>Differential and Integral Calculus 10</td>
</tr>
<tr>
<td>21-122</td>
<td>Integration and Approximation 10</td>
</tr>
<tr>
<td>or 21-124</td>
<td>Calculus II for Biologists and Chemists 10</td>
</tr>
<tr>
<td>03-121</td>
<td>Modern Biology 9</td>
</tr>
<tr>
<td>or 03-151</td>
<td>Honors Modern Biology 9</td>
</tr>
<tr>
<td>03-201</td>
<td>Undergraduate Colloquium for Sophomores 1</td>
</tr>
<tr>
<td>03-220</td>
<td>Genetics 9</td>
</tr>
<tr>
<td>09-105</td>
<td>Introduction to Modern Chemistry I 10</td>
</tr>
<tr>
<td>09-106</td>
<td>Modern Chemistry II 10</td>
</tr>
<tr>
<td>09-207</td>
<td>Techniques in Quantitative Analysis 9-12</td>
</tr>
<tr>
<td>or 09-221</td>
<td>Laboratory I: Introduction to Chemical Analysis 10</td>
</tr>
<tr>
<td>or 03-124</td>
<td>Modern Biology Laboratory 10</td>
</tr>
<tr>
<td>09-217</td>
<td>Organic Chemistry I 9</td>
</tr>
<tr>
<td>or 33-122</td>
<td>Physics II for Biological Sciences &amp; Chemistry Students 9</td>
</tr>
<tr>
<td>33-121</td>
<td>Physics I for Science Students 12</td>
</tr>
<tr>
<td>15-110</td>
<td>Principles of Computing 10-12</td>
</tr>
<tr>
<td>or 15-112</td>
<td>Fundamentals of Programming and Computer Science 10</td>
</tr>
<tr>
<td>or 02-201</td>
<td>Programming for Scientists 10</td>
</tr>
<tr>
<td>36-201</td>
<td>Statistical Reasoning and Practice 2</td>
</tr>
<tr>
<td>or 36-217</td>
<td>Probability Theory and Random Processes 9</td>
</tr>
<tr>
<td>36-247</td>
<td>Statistics for Lab Sciences 9</td>
</tr>
<tr>
<td>or 36-225</td>
<td>Introduction to Probability Theory 9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>108-113</strong></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>85-219</td>
<td>Biological Foundations of Behavior 9</td>
</tr>
<tr>
<td>or 03-161</td>
<td>Molecules to Mind 10</td>
</tr>
<tr>
<td>85-211</td>
<td>Cognitive Psychology 9</td>
</tr>
<tr>
<td>or 85-213</td>
<td>Human Information Processing and Artificial Intelligence 9</td>
</tr>
<tr>
<td>03-362</td>
<td>Cellular Neuroscience 9</td>
</tr>
<tr>
<td>03-363</td>
<td>Systems Neuroscience 9</td>
</tr>
<tr>
<td>15-386</td>
<td>Neural Computation 9</td>
</tr>
<tr>
<td>or 85-419</td>
<td>Introduction to Parallel Distributed Processing 9</td>
</tr>
<tr>
<td>or 02-319</td>
<td>Genomics and Epigenetics of the Brain 9</td>
</tr>
<tr>
<td>or 86-375</td>
<td>Computational Perception 9</td>
</tr>
</tbody>
</table>

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 12

** 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 9
42-202 Physiology 9
42-203 Biomedical Engineering Laboratory 9

NOTE: VERY Limited Seating Available for 42-203

** 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 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 10
21-241 Matrices and Linear Transformations 10
or 21-240 Matrix Algebra with Applications 10

* 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 Units
42-631 Neural Data Analysis 9
or 86-631 Neural Data Analysis 9
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 9
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 9
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 9
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 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

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

Degree Requirements:

**Biological Sciences**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>03-121</td>
<td>Modern Biology</td>
<td>9</td>
</tr>
<tr>
<td>or 03-151</td>
<td>Honors Modern Biology</td>
<td></td>
</tr>
<tr>
<td>03-220</td>
<td>Genetics</td>
<td>9</td>
</tr>
<tr>
<td>03-231/232</td>
<td>Biochemistry I</td>
<td>9</td>
</tr>
<tr>
<td>03-320</td>
<td>Cell Biology</td>
<td>9</td>
</tr>
<tr>
<td>03-343</td>
<td>Experimental Techniques in Molecular Biology</td>
<td>12</td>
</tr>
<tr>
<td>03-411</td>
<td>Topics in Research</td>
<td>1</td>
</tr>
<tr>
<td>03-412</td>
<td>Topics in Research</td>
<td>1</td>
</tr>
<tr>
<td>03-xxx</td>
<td>General Biology Elective</td>
<td>9</td>
</tr>
<tr>
<td>03-3x6</td>
<td>Advanced Biology Elective</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Total Biology units</strong></td>
<td><strong>77</strong></td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-120</td>
<td>Differential and Integral Calculus</td>
<td>10</td>
</tr>
<tr>
<td>21-122</td>
<td>Integration and Approximation</td>
<td>10</td>
</tr>
<tr>
<td>or 21-124</td>
<td>Calculus II for Biologists and Chemists</td>
<td></td>
</tr>
<tr>
<td>36-247</td>
<td>Statistics for Lab Sciences</td>
<td>9</td>
</tr>
<tr>
<td>or 36-201</td>
<td>Statistical Reasoning and Practice</td>
<td></td>
</tr>
<tr>
<td>36-309</td>
<td>Experimental Design for Behavioral and Social Sciences</td>
<td>9</td>
</tr>
<tr>
<td>33-121</td>
<td>Physics I for Science Students</td>
<td>12</td>
</tr>
<tr>
<td>15-110</td>
<td>Principles of Computing</td>
<td>10-12</td>
</tr>
<tr>
<td>or 15-112</td>
<td>Fundamentals of Programming and Computer Science</td>
<td></td>
</tr>
<tr>
<td>or 02-201</td>
<td>Programming for Scientists</td>
<td></td>
</tr>
<tr>
<td>10-10x</td>
<td>Computing at Carnegie Mellon</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Total Science units</strong></td>
<td><strong>63-65</strong></td>
</tr>
</tbody>
</table>

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

**Chemistry**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>09-105</td>
<td>Introduction to Modern Chemistry I</td>
<td>10</td>
</tr>
<tr>
<td>09-106</td>
<td>Modern Chemistry II</td>
<td>10</td>
</tr>
<tr>
<td>09-217</td>
<td>Organic Chemistry I</td>
<td>9</td>
</tr>
</tbody>
</table>
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)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-120 Differential and Integral Calculus</td>
<td>10</td>
</tr>
<tr>
<td>21-122 Integration and Approximation</td>
<td>10</td>
</tr>
<tr>
<td>or 21-124 Calculus II for Biologists and Chemists</td>
<td></td>
</tr>
</tbody>
</table>

**Statistical Reasoning (9 units)**

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

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>36-200 Reasoning with Data</td>
<td>9</td>
</tr>
<tr>
<td>36-201 Statistical Reasoning and Practice</td>
<td>9</td>
</tr>
<tr>
<td>36-202 Methods for Statistics and Data Science</td>
<td>9</td>
</tr>
<tr>
<td>21-325 Probability</td>
<td>9</td>
</tr>
<tr>
<td>36-217 Probability Theory and Random Processes</td>
<td>9</td>
</tr>
<tr>
<td>36-225 Introduction to Probability Theory</td>
<td>9</td>
</tr>
<tr>
<td>36-247 Statistics for Lab Sciences</td>
<td>9</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>76-101 Interpretation and Argument</td>
<td>9</td>
</tr>
<tr>
<td>or 76-102 Advanced First Year Writing: Special Topics</td>
<td></td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>79-104 Global Histories</td>
<td>9</td>
</tr>
</tbody>
</table>

**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:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>99-241 Revolutions of Circularity</td>
<td>9</td>
</tr>
<tr>
<td>99-242 Meaning Across the Millennia</td>
<td>9</td>
</tr>
<tr>
<td>99-243 Light from the Enlightenment</td>
<td>9</td>
</tr>
<tr>
<td>99-245 Energy: Science, Society and Communication</td>
<td>9</td>
</tr>
</tbody>
</table>

**Computational Reasoning (9-12 units)**

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

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

**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.

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>03-121 Modern Biology</td>
<td>9-10</td>
</tr>
<tr>
<td>or 03-151 Honors Modern Biology</td>
<td></td>
</tr>
<tr>
<td>03-230 Intro to Mammalian Physiology</td>
<td>9</td>
</tr>
<tr>
<td>or 42-202 Physiology</td>
<td></td>
</tr>
<tr>
<td>09-105 Introduction to Modern Chemistry I</td>
<td>10</td>
</tr>
<tr>
<td>or 09-107 Honors Chemistry: Fundamentals, Concepts and Applications</td>
<td></td>
</tr>
<tr>
<td>09-106 Modern Chemistry II</td>
<td>10</td>
</tr>
<tr>
<td>33-121 Physics I for Science Students</td>
<td>12</td>
</tr>
<tr>
<td>or 33-151 Matter and Interactions I</td>
<td></td>
</tr>
<tr>
<td>33-142 Physics II for Engineering and Physics Students</td>
<td>9-12</td>
</tr>
<tr>
<td>or 33-151 Matter and Interactions I</td>
<td></td>
</tr>
<tr>
<td>or 33-122 Physics II for Biological Sciences &amp; Chemistry Students</td>
<td></td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>80-100 Introduction to Philosophy</td>
<td>9</td>
</tr>
<tr>
<td>80-130 Introduction to Ethics</td>
<td>9</td>
</tr>
<tr>
<td>80-150 Nature of Reason</td>
<td>9</td>
</tr>
<tr>
<td>80-180 Nature of Language</td>
<td>9</td>
</tr>
<tr>
<td>80-221 Philosophy of Social Science</td>
<td>9</td>
</tr>
<tr>
<td>80-230 Ethical Theory</td>
<td>9</td>
</tr>
<tr>
<td>80-241 Ethical Judgments in Professional Life</td>
<td>9</td>
</tr>
<tr>
<td>80-270 Philosophy of Mind</td>
<td>9</td>
</tr>
<tr>
<td>85-102 Introduction to Psychology</td>
<td>9</td>
</tr>
<tr>
<td>85-211 Cognitive Psychology</td>
<td>9</td>
</tr>
<tr>
<td>85-221 Principles of Child Development</td>
<td>9</td>
</tr>
<tr>
<td>85-241 Social Psychology</td>
<td>9</td>
</tr>
<tr>
<td>85-251 Personality</td>
<td>9</td>
</tr>
<tr>
<td>85-261 Abnormal Psychology</td>
<td>9</td>
</tr>
<tr>
<td>88-120 Reason, Passion and Cognition</td>
<td>9</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>36-303 Sampling, Survey and Society</td>
<td>9</td>
</tr>
<tr>
<td>70-332 Business, Society and Ethics</td>
<td>9</td>
</tr>
<tr>
<td>73-102 Principles of Microeconomics</td>
<td>9</td>
</tr>
<tr>
<td>73-103 Principles of Macroeconomics</td>
<td>9</td>
</tr>
<tr>
<td>73-230 Intermediate Microeconomics</td>
<td>9</td>
</tr>
<tr>
<td>79-266 Russian History: From Communism to Capitalism</td>
<td>9</td>
</tr>
<tr>
<td>79-318 Sustainable Social Change: History and Practice</td>
<td>9</td>
</tr>
<tr>
<td>79-331 Body Politics: Women and Health in America</td>
<td>9</td>
</tr>
<tr>
<td>79-350 Early Christianity</td>
<td>9</td>
</tr>
<tr>
<td>80-135 Introduction to Political Philosophy</td>
<td>9</td>
</tr>
<tr>
<td>80-135 Introduction to Political Philosophy</td>
<td>9</td>
</tr>
</tbody>
</table>
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.

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)

- Survey of Forms: Fiction
- Survey of Forms: Nonfiction
- Survey of Forms: Poetry
- Roots of Rock & Roll
- Philosophy of Science
- Any Elementary Modern Language course
- Any Intermediate Modern Language course
- Revolutions of Circularity
- Meaning Across the Millennia

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.

- Survey of Western Music History
- Managing Across Cultures
- Comedy
- Introduction to African American Literature
- Introduction to Gender Studies
- Introduction to Anthropology
- Development of American Culture
- Development of European Culture
- African American History: Africa to the Civil War
- African American History: Reconstruction to the Present
- Mayan America
- The Last Emperors: Chinese History and Society, 1600-1900
- Sustainable Social Change: History and Practice
- Medicine and Society
- Roots of Rock & Roll
- Introduction to Philosophy
- Ancient Philosophy
- Modern Philosophy
- Continental Philosophy
- Analytic Philosophy
- Pragmatism
- Empiricism and Rationalism
- Introduction to Japanese Language and Culture
- Topics in Russian Language and Culture
- Introduction to French Culture
- The Francophone World
- Introduction to Chinese Language and Culture
- Spain: Language and Culture
- Latin America: Language and Culture
- U.S. Latinos: Language and Culture
- Introduction to Hispanic Literary and Cultural Studies
- The Faust Legend at Home and Abroad
- Topics in French and Francophone Studies
- Topics in German Literature and Culture
- Studies in Latin American Literature and Culture