The MSE in Scientific Computing (SCMP) program at Penn provides multifaceted education in the fundamentals and applications of computational science. This education program provides a rigorous computational foundation for applications to a broad range of scientific disciplines. An education in SCMP combines a comprehensive set of core courses centered on numerical methods, algorithm development for high performance computational platforms, and the analysis of large data, and offers flexibility to specialize in different computational science application areas. Students may elect to pursue a thesis in computationally-oriented research within the School of Engineering and Applied Science.

We welcome applications from candidates who have a strong background in physical or theoretical sciences, engineering, math, or computer science. Some experience with computer programming is also strongly recommended.

For more information: https://pics.upenn.edu/masters-science-engineering-scientific-computing/

## Curriculum

10 course units are required for the MSE in Scientific Computing.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Course Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Foundations</strong></td>
<td></td>
</tr>
<tr>
<td>CIT 590</td>
<td>Programming Languages and Techniques</td>
<td>1</td>
</tr>
<tr>
<td>or CIT 591</td>
<td>Introduction to Software Development</td>
<td></td>
</tr>
<tr>
<td>CIT 596</td>
<td>Algorithms and Computation</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Core Requirements</strong></td>
<td></td>
</tr>
<tr>
<td>ENM 502</td>
<td>Numerical Methods and Modeling</td>
<td>1</td>
</tr>
<tr>
<td>CIS 545</td>
<td>Big Data Analytics</td>
<td>1</td>
</tr>
<tr>
<td>Select 1 of the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIS 519</td>
<td>Applied Machine Learning</td>
<td>1</td>
</tr>
<tr>
<td>or CIS 520</td>
<td>Machine Learning</td>
<td></td>
</tr>
<tr>
<td>or STAT 571</td>
<td>Modern Data Mining</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Technical &amp; Depth Area Electives</strong></td>
<td></td>
</tr>
<tr>
<td>Select 2 Simulation Methods for Natural Science/Engineering courses</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Select Thesis/Independent Study or 2 Natural Science/Engineering electives</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Select 1 Technical &amp; Depth Area elective ¹</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Total Course Units</strong></td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

### Technical & Depth Area Electives

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Course Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Applications</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thesis/Independent Study ²</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bio medicine</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BE 521</td>
<td>Brain-Computer Interfaces</td>
<td></td>
</tr>
<tr>
<td>BE 566</td>
<td>Networked Neuroscience</td>
<td></td>
</tr>
<tr>
<td>BE 567</td>
<td>Mathematical Computation Methods for Modeling Biological Systems</td>
<td></td>
</tr>
</tbody>
</table>

### Social/Network Science

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Course Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 705</td>
<td>Econometrics I: Fundamentals</td>
<td></td>
</tr>
<tr>
<td>ECON 706</td>
<td>Econometrics II: Methods &amp; Models</td>
<td></td>
</tr>
<tr>
<td>ECON 721</td>
<td>Econometrics III: Advanced Techniques of Cross-Section Econometrics</td>
<td></td>
</tr>
<tr>
<td>ECON 722</td>
<td>Econometrics IV: Advanced Techniques of Time-Series Econometrics</td>
<td></td>
</tr>
<tr>
<td>MKTG 476/776</td>
<td>Applied Probability Models in Marketing</td>
<td></td>
</tr>
</tbody>
</table>

### Natural Science/Engineering ³

#### Chemical Engineering:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Course Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBE 621</td>
<td>Advanced Chemical Kinetics and Reactor Design</td>
<td></td>
</tr>
<tr>
<td>CBE 641</td>
<td>Transport Processes II (Nanoscale Transport)</td>
<td></td>
</tr>
<tr>
<td>CBE 535</td>
<td>Interfacial Phenomena</td>
<td></td>
</tr>
</tbody>
</table>

#### Mechanical Engineering:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Course Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEAM 545</td>
<td>Aerodynamics</td>
<td></td>
</tr>
<tr>
<td>MEAM 537</td>
<td>Nanotribology</td>
<td></td>
</tr>
<tr>
<td>MEAM 575</td>
<td>Micro and Nano Fluidics</td>
<td></td>
</tr>
</tbody>
</table>

#### Bioengineering:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Course Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BE 555</td>
<td>Nanoscale Systems Biology</td>
<td></td>
</tr>
<tr>
<td>BE 546/547</td>
<td>Fundamental Techniques of Imaging I</td>
<td></td>
</tr>
<tr>
<td>BE 537</td>
<td>Biomedical Image Analysis</td>
<td></td>
</tr>
</tbody>
</table>

#### Materials Science and Engineering:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Course Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 537</td>
<td>Nanotribology</td>
<td></td>
</tr>
<tr>
<td>MSE 540</td>
<td>Phase Transformations</td>
<td></td>
</tr>
<tr>
<td>MSE 550</td>
<td>Elasticity and Micromechanics of Materials</td>
<td></td>
</tr>
</tbody>
</table>

### Methods

#### Data-centric Programming

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Course Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIS 505</td>
<td>Software Systems</td>
<td></td>
</tr>
<tr>
<td>CIS 573</td>
<td>Software Engineering</td>
<td></td>
</tr>
<tr>
<td>CIT 595</td>
<td>Computer Systems Programming</td>
<td></td>
</tr>
<tr>
<td>CIS 552</td>
<td>Advanced Programming</td>
<td></td>
</tr>
<tr>
<td>CIS 555</td>
<td>Internet and Web Systems</td>
<td></td>
</tr>
<tr>
<td>CIS 559</td>
<td>Programming and Problem Solving</td>
<td></td>
</tr>
</tbody>
</table>

#### Data Collection, Representation, Management and Retrieval

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Course Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIS 550</td>
<td>Database and Information Systems</td>
<td></td>
</tr>
<tr>
<td>STAT 920</td>
<td>Sample Survey Methods</td>
<td></td>
</tr>
<tr>
<td>STAT 921</td>
<td>Observational Studies</td>
<td></td>
</tr>
</tbody>
</table>

#### Data Analysis, Artificial Intelligence

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Course Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIS 530</td>
<td>Computational Linguistics</td>
<td></td>
</tr>
<tr>
<td>CIS 580</td>
<td>Machine Perception</td>
<td></td>
</tr>
<tr>
<td>CIS 581</td>
<td>Computer Vision &amp; Computational Photography</td>
<td></td>
</tr>
<tr>
<td>CIS 680</td>
<td>Advanced Topics in Machine Perception</td>
<td></td>
</tr>
<tr>
<td>CIS 625</td>
<td>Theory of Machine Learning</td>
<td></td>
</tr>
<tr>
<td>ESE 545</td>
<td>Data Mining: Learning from Massive Datasets</td>
<td></td>
</tr>
<tr>
<td>STAT 571</td>
<td>Modern Data Mining</td>
<td></td>
</tr>
<tr>
<td>CIS 700</td>
<td>Special Topics</td>
<td></td>
</tr>
<tr>
<td>CIS 502</td>
<td>Analysis of Algorithms</td>
<td></td>
</tr>
<tr>
<td>Course</td>
<td>Title</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>CIS 677</td>
<td>Advanced Topics in Algorithms and Complexity</td>
<td></td>
</tr>
<tr>
<td>CIT 596</td>
<td>Algorithms and Computation</td>
<td></td>
</tr>
<tr>
<td>CIS 521</td>
<td>Artificial Intelligence</td>
<td></td>
</tr>
<tr>
<td>ESE 650</td>
<td>Learning in Robotics</td>
<td></td>
</tr>
<tr>
<td>STAT 974</td>
<td>Modern Regression for the Social, Behavioral and Biological Sciences</td>
<td></td>
</tr>
</tbody>
</table>

**Simulation Methods for Natural Science/Engineering**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 561</td>
<td>Atomic Modeling in Materials Science</td>
</tr>
<tr>
<td>BE 559</td>
<td>Multiscale Modeling of Chemical and Biological Systems</td>
</tr>
<tr>
<td>CBE 525</td>
<td>Molecular Modeling and Simulations</td>
</tr>
<tr>
<td>CBE 544</td>
<td>Computational Science of Energy and Chemical Transformations</td>
</tr>
<tr>
<td>MEAM 527</td>
<td>Finite Element Analysis</td>
</tr>
<tr>
<td>MEAM 646</td>
<td>Computational Mechanics</td>
</tr>
</tbody>
</table>

**Modelling**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESE 505</td>
<td>Feedback Control Design and Analysis</td>
</tr>
<tr>
<td>ENM 540</td>
<td>Topics In Computational Science and Engineering</td>
</tr>
</tbody>
</table>

**Statistics, Mathematical Foundations**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENM 502</td>
<td>Numerical Methods and Modeling</td>
</tr>
<tr>
<td>CIS 515</td>
<td>Fundamentals of Linear Algebra and Optimization</td>
</tr>
<tr>
<td>AMCS 510</td>
<td>Complex Analysis</td>
</tr>
<tr>
<td>ESE 504</td>
<td>Intro to Linear, Nonlinear and Integer Optimization</td>
</tr>
<tr>
<td>STAT 621</td>
<td>Accelerated Regression Analysis for Business</td>
</tr>
<tr>
<td>STAT 533</td>
<td>Stochastic Processes</td>
</tr>
<tr>
<td>ESE 605</td>
<td>Modern Convex Optimization</td>
</tr>
<tr>
<td>ESE 674</td>
<td>Information Theory</td>
</tr>
</tbody>
</table>

1. Or a free elective (subject to approval)
2. Select 2 course units of SCMP 597 Thesis Research or SCMP 599 Independent Study.
3. Generally, any course in which the primary focus is a physical/chemical/biological/mechanical application area that may be studied computationally is allowed.

The degree and major requirements displayed are intended as a guide for students entering in the Fall of 2021 and later. Students should consult with their academic program regarding final certifications and requirements for graduation.