DATA SCIENCE, MSE

Penn's Master of Science in Engineering (MSE) in Data Science prepares students for a wide range of data-centric careers, whether in technology and engineering, consulting, science, policy-making, or understanding patterns in literature, art or communications.

The Data Science Program can typically be completed in one-and-a-half to two years. It blends leading-edge courses in core topics such as machine learning, big data analytics, and statistics, with a variety of electives and an opportunity to apply these techniques in a domain specialization of choice.

The domain specialization offers both preparatory coursework and a thesis or practicum in a data science application area. Potential areas of specialization include network science (the Warren Center for Network and Data Science), digital humanities (the Price Lab for Digital Humanities), biomedicine (the Institute for Biomedical Informatics), and public policy (the Penn Wharton Budget Model and the Annenberg Center for Public Policy) — as well as more traditional opportunities in Computer and Information Science and Electrical and Systems Engineering. For students interested in applying data analysis and modeling to other areas within engineering and the physical sciences, Penn offers a specialized and synergistic program in Scientific Computing.

For more information: https://dats.seas.upenn.edu/program/

Curriculum

10 course units are required for the Data Science degree.¹

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Course Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIT 590</td>
<td>Programming Languages and Techniques 1</td>
<td></td>
</tr>
<tr>
<td>or CIT 591</td>
<td>Introduction to Software Development 1</td>
<td></td>
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<tr>
<td>Select one of the following:</td>
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<tr>
<td>CIS 515</td>
<td>Fundamentals of Linear Algebra and Optimization 1</td>
<td></td>
</tr>
<tr>
<td>or MATH 513</td>
<td>Computational Linear Algebra 1</td>
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Core Requirements (3 cu's)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Course Units</th>
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</thead>
<tbody>
<tr>
<td>ESE 542</td>
<td>Statistics for Data Science 1</td>
<td></td>
</tr>
<tr>
<td>CIS 545</td>
<td>Big Data Analytics 1</td>
<td></td>
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</tbody>
</table>

Select one of the following:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Course Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIS 519</td>
<td>Applied Machine Learning 1</td>
<td></td>
</tr>
<tr>
<td>or CIS 520</td>
<td>Machine Learning 1</td>
<td></td>
</tr>
<tr>
<td>or STAT 571</td>
<td>Modern Data Mining 1</td>
<td></td>
</tr>
<tr>
<td>or ENM 531</td>
<td>Data-driven Modeling and Probabilistic Scientific Computing 1</td>
<td></td>
</tr>
<tr>
<td>or ESE 545</td>
<td>Data Mining: Learning from Massive Datasets 1</td>
<td></td>
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Technical Electives (5 cu's)

Students must choose from at least 3 of the buckets listed below

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Course Units</th>
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</thead>
<tbody>
<tr>
<td>ESE 545</td>
<td>Statistics for Data Science 1</td>
<td></td>
</tr>
<tr>
<td>CIS 521</td>
<td>Artificial Intelligence 1</td>
<td></td>
</tr>
<tr>
<td>CIS 522</td>
<td>Deep Learning for Data Science 1</td>
<td></td>
</tr>
<tr>
<td>CIS 530</td>
<td>Computational Linguistics 1</td>
<td></td>
</tr>
<tr>
<td>CIS 580</td>
<td>Machine Perception 1</td>
<td></td>
</tr>
</tbody>
</table>

The ten course units for the Data Science degree are divided into three categories: Foundations, Core Requirements and Technical Electives. (As long as the prerequisites for the courses are met, students can complete these courses in any sequence)

Applications

A. Title/Thesis/Practicum (two course units)

Register for 2 course units of DATS 597 Master’s Thesis Research/Master’s Thesis or 2 course units of DATS 599 Master’s Indep Study/Master’s Independent Study.²

B. Bio medicine

BE 521 Brain-Computer Interfaces
BE 566 Networked Neuroscience
BE 567 Mathematical Computation Methods for Modeling Biological Systems
CIS 536 Fundamentals of Computational Biology
CIS 537 Biomedical Image Analysis
PHYS 585 Theoretical and Computational Neuroscience

C. Social/Network Science

ECON 705 Econometrics I: Fundamentals
ECON 721 Econometrics III: Advanced Techniques of Cross-Section Econometrics
ECON 722 Econometrics IV: Advanced Techniques of Time-Series Econometrics
MKTG 776 Applied Probability Models in Marketing

D. Data-centric Programming

CIS 505 Software Systems
CIS 550 Database and Information Systems
CIS 552 Advanced Programming
CIS 555 Internet and Web Systems
CIS 559 Programming and Problem Solving
CIS 573 Software Engineering
CIT 595 Computer Systems Programming

E. Surveys and Statistical Methods

STAT 910 Econometrics I: Fundamentals
STAT 920 Sample Survey Methods
STAT 921 Observational Studies
STAT 974 Modern Regression for the Social, Behavioral and Biological Sciences
STAT 621 Accelerated Regression Analysis for Business
STAT 711 Forecasting Methods for Management
STAT 722 Predictive Analytics for Business (formerly STAT 622)

F. Data Analysis, Artificial Intelligence

CIS 521 Artificial Intelligence
CIS 522 Deep Learning for Data Science
CIS 530 Computational Linguistics
CIS 580 Machine Perception

¹ The course units for the Data Science degree are divided into three categories: Foundations, Core Requirements and Technical Electives. (As long as the prerequisites for the courses are met, students can complete these courses in any sequence)

² For more information: https://dats.seas.upenn.edu/program/
CIS 581  Computer Vision & Computational Photography
CIS 620  Advanced Topics in Machine Learning
CIS 680  Advanced Topics in Machine Perception
ESE 650  Learning in Robotics
STAT 571  Modern Data Mining
ESE 546  Principles of Deep Learning

G. Simulation Methods for Natural Science / Engineering
CBE 525  Molecular Modeling and Simulations
CBE 544  Computational Science of Energy and Chemical Transformations
MEAM 527  Finite Element Analysis
MEAM 646  Computational Mechanics
MSE 561  Atomic Modeling in Materials Science
BE 559  Multiscale Modeling of Chemical Systems
BE 567  Mathematical Computation Methods for Modeling Biological Systems

H. Mathematical and Algorithmic Foundations
AMCS 514  Advanced Linear Algebra
CIS 502  Analysis of Algorithms
CIS 625  Theory of Machine Learning
CIS 677  Advanced Topics in Algorithms and Complexity
ENM 502  Numerical Methods and Modeling
ENM 531  Data-driven Modeling and Probabilistic Scientific Computing
ESE 504  Intro to Linear, Nonlinear and Integer Optimization
ESE 545  Data Mining: Learning from Massive Datasets
ESE 503  Simulation Modeling and Analysis
ESE 605  Modern Convex Optimization
ESE 674  Information Theory
STAT 533  Stochastic Processes
STAT 512  Mathematical Statistics
STAT 927  Bayesian Statistical Theory and Methods
CIT 596  Algorithms and Computation

1. Students must choose courses from 3 different buckets.
2. Suggestions for projects will be provided to students. Students may choose from these suggested projects or may also come up with their own project/advisor ideas. Students will be mentored jointly by the Program Director and by an advisor in the area of the project, and must receive approval by Faculty Director.

The degree and major requirements displayed are intended as a guide for students entering in the Fall of 2020 and later. Students should consult with their academic program regarding final certifications and requirements for graduation.