DATA SCIENCE

Overview

Data Science is a rapidly growing academic discipline fueled by the proliferation of rich and complex data emerging from activities in science, industry, and governments. As a result, there is strong demand for data science professionals today in Iowa as well as across the nation and globe, and this market is expected to continue to grow in the next decade. The data science programs are intended for students who wish to study the data science discipline for its own sake as well as for students studying any discipline at Iowa State University with the goal of enabling them to work in data science. The courses in the data science program are designed to provide students with the requisite background that would enable them to take jobs with significant data science components, e.g., establishing and operating data analysis pipelines. The capstone will provide an opportunity for students to apply data science concepts to a domain problem while working in a multi-disciplinary team setting.

The Data Science major is intended for students with strong quantitative backgrounds and has the goal of educating students on the technical fundamentals of Data Science, with a focus on developing the knowledge and skills needed to transform data into insights. The major is an excellent opportunity for individuals who want to prepare themselves for the exciting Data Scientist positions that are in high demand today.

The minor in Data Science is intended for students studying any discipline at Iowa State and is designed to give students an in-depth understanding of data science as it is applied to a variety of domains.

The certificate in Data Science is intended for students studying any discipline at Iowa State and is designed to prepare them for future work with significant data science components. The capstone will provide an opportunity for students to apply data science concepts to a domain problem while working in a multi-disciplinary team setting.

Student Learning Outcomes for Data Science Major

After successfully completing the program, students majoring in Data Science will demonstrate

1. an understanding of and an ability to apply the following data science concepts, tools and methods to data analysis pipelines:
    a. data acquisition
    b. data preprocessing
    c. exploratory data analysis
    d. inferential and predictive thinking, modeling and analysis
    e. computational thinking, data structures, and algorithms
2. an understanding of ethical, legal, societal, and economic concerns in the application of data science concepts

3. an ability to visualize, interpret and communicate the output of data analysis pipelines to stakeholders
4. an ability to function on multi-disciplinary teams using concepts and tools from data science

See Undergraduate Minor and Undergraduate Certificate subpages for the respective learning outcomes.

Data Science Major

Purpose

The Bachelor of Science degree program in Data Science is intended for students with strong quantitative backgrounds and has the goal of educating students on the technical fundamentals of data sciences, with a focus on developing the knowledge and skills needed to manage and analyze large-scale, heterogeneous data to address a wide range of problems.

Requirements

The B.S. in Data Science consists of 120 total credit hours including: (1) 39 credit hours in the major core, three credits of which constitute a capstone course that is expected to provide experiential learning; (2) 9 credit hours in an application emphasis area to examine applications and theory of data sciences in a specific area; and (3) 23 credit hours of foundation courses. The capstone course will provide an opportunity for students to apply data science concepts to an application area while working in a multi-disciplinary team setting.

Data Science Major Requirements

Data Science Core Courses		39
DS 110	Orientation to Data Science	R
DS 201	Introduction to Data Science	3
DS 202	Data Acquisition and Exploratory Data Analysis	3
DS 303	Concepts and Applications of Machine Learning	3
DS 401	Data Science Capstone	3
COM S 228	Introduction to Data Structures	3
COM S 230	Discrete Computational Structures	3
or CPR E 310	Theoretical Foundations of Computer Engineering	
COM S 311	Introduction to the Design and Analysis of Algorithms	3
COM S 363	Introduction to Database Management Systems	3
CPR E 419	Software Tools for Large Scale Data Analysis	4
STAT 301	Intermediate Statistical Concepts and Methods	4
STAT 347	Probability and Statistical Theory for Data Science	4
STAT 477	Introduction to Categorical Data Analysis	3

At least 9 credits from the following categories to fulfill the emphasis area:

At least 6 credits from courses at the 300, 400, or 500 level from the following designations:		6
A B E, ADVRT, AGRON, AN S, ARCH, BCBIO, COM S, C R P, CPR E, CYB E, CYBSC, DS, E E, ECON, FIN, GIS, I E, JL MC, LA, LING, MATH, MIS, MKT, POL S, S E, SOC, STAT, TSM		
At least 3 credits from one of the following courses:		3
BCBIO 401	Bioinformatics of Sequences	
BCBIO 406	Bioinformatics of OMICS	
COM S 342	Principles of Programming Languages	
COM S 413	Program Analysis	
COM S 421	Logic for Mathematics and Computer Science	
COM S 424	Introduction to High Performance Computing	
COM S 426	Introduction to Parallel Algorithms and Programming	
COM S 435	Algorithms for Large Data Sets: Theory and Practice	
COM S 440	Principles and Practice of Compiling	
COM S 454	Distributed Systems	
COM S 461	Principles and Internals of Database Systems	
COM S 474	Introduction to Machine Learning	
CPR E 388	Embedded Systems II: Mobile Platforms	
CPR E 416	Software Evolution and Maintenance	
CPR E 425	High Performance Computing for Scientific and Engineering Applications	
CPR E 431	Basics of Information System Security	
E E 425	Machine learning: A Signal Processing Perspective	
DS 490X	Independent Study	
DS 490HX	Independent Study	
I E 312	Optimization	
I E 483	Data Mining	
I E 487	Big Data Analytics and Optimization	
MATH 373	Introduction to Scientific Computing	
MATH 407	Applied Linear Algebra	
MATH 424	Introduction to High Performance Computing	
MATH 481	Numerical Methods for Differential Equations	
STAT 471	Introduction to Experimental Design	
STAT 473	Introduction to Survey Sampling	
STAT 475	Introduction to Multivariate Data Analysis	
Total Credits		**9**

Toward satisfying pre-requisites and requirements of the College of Liberal Arts and Sciences, the following courses or their equivalents are also required:

COM S 127	Introduction to Computer Programming	3
COM S 227	Object-oriented Programming	4
MATH 165	Calculus I	4
MATH 166	Calculus II	4
MATH 265	Calculus III	4
MATH 207	Matrices and Linear Algebra	3
STAT 201	Introduction to Statistical Concepts and Methods	4
World Language 3 years in high school or 1 year in college		0 - 8
Natural Science		8
Social Science		9
Arts and Humanities		12
LAS 203	Professional Career Preparation	1

The following courses meet the communication proficiency requirement:

LIB 160	Introduction to College Level Research	1
ENGL 150	Critical Thinking and Communication	3
ENGL 250	Written, Oral, Visual, and Electronic Composition	3
One of the following:		
ENGL 302	Business Communication	3
ENGL 314	Technical Communication	3
ENGL 332	Visual Communication of Quantitative Information (cross-listed as STAT 332)	3

As majors in the College of Liberal Arts and Sciences, Data Science students must meet College of Liberal Arts and Sciences (http://catalog.iastate.edu/previouscatalogs/2023-2024/collegeofliberalartsandsciences/#lascollegerequirementstext) and University-wide requirements (http://catalog.iastate.edu/previouscatalogs/2023-2024/collegescurricula/) for graduation in addition to those stated above for the major.

LAS majors require a minimum of 120 credits, including a minimum of 45 credits at the 300/400 level or above taken at a four-year college. All such credits, including courses taken on a pass/not pass basis, may be used to meet this requirement.. You must also complete the LAS world language requirement and career proficiency requirement.

Students in all ISU majors must complete a three-credit course in U.S. diversity and a three-credit course in international perspectives. Check (http://www.registrar.iastate.edu/courses/div-ip-guide.html) for a list of approved courses. Discuss with your advisor how the two courses that you select can be applied to your graduation plan.

According to the university-wide Communication Proficiency Grade Requirement, students must demonstrate their communication proficiency by earning a grade of C or better in ENGL 250. The Data

Science program requires a C or higher in the upper-level ENGL course (302, 314, or 332).

Four Year Plan
B.S., Data Science

Freshman

Fall	Credits	Spring	Credits
DS 110		R MATH 166	4
MATH 165	4	COM S 227	4
COM S 127	3	STAT 201	4
ENGL 150	3	ENGL 250	3
LIB 160	1		
Social Science	3		
	14		**15**

Sophomore

Fall	Credits	Spring	Credits
DS 201	3	DS 202	3
MATH 265	4	MATH 207	3
COM S 228	3	COM S 230 or CPR E 310	3
STAT 301	4	Social Science/International Perspectives	3
Arts and Humanities/U.S. Diversity	3	Arts and Humanities	3
		LAS 203	1
	17		**16**

Junior

Fall	Credits	Spring	Credits
DS 303	3	COM S 363	3
STAT 347	4	STAT 477	3
COM S 311	3	Arts and Humanities	3
Arts and Humanities (300+ level)	3	Natural Science	4
Elective or World Language	3-4	Elective or World Language	3-4
	16-17		**16-17**

Senior

Fall	Credits	Spring	Credits
Application Emphasis Area	3	DS 401	3
Application Emphasis Area	3	CPR E 419	4
ENGL 302, 314, or 332	3	Application Emphasis Area	3
Natural Science	4	Social Science (300+ Level)	3
	13		**13**

The major elective courses will come from Data Science emphasis areas as outlined on the Undergraduate Major page. A student must take at least 9 credits of 300+ courses from a wide variety of designations. Additionally, 3 credits must be chosen from a list of elective courses with a data or analysis emphasis.

All students are required to take at least 45 hours of courses at the 300+ level or above. This may require taking additional electives.

Data Science Minor
Purpose

The minor in data science is intended for students studying any discipline at Iowa State and is designed to give students an in-depth understanding of data science as it is applied to a variety of domains. The minor in data science will prepare students with the technical and communication skills to enter the workforce as domain experts with data science skills.

Learning Outcomes for Data Science Minor

After completing the minor in data science, students will demonstrate:

- an ability to apply data science concepts, tools and technologies to data analysis pipelines,
- an understanding of ethical, legal, societal, and economic concerns in application of data science concepts,
- an ability to visualize, interpret and communicate the output of data analysis pipelines to stakeholders, and
- an ability to function on multi-disciplinary teams using concepts and tools from data science.

Requirements

The minor in data science requires the completion of 15 credit hours, including 9 credits from the data science core and 6 credits from approved data science electives.

At least 6 credits in courses numbered 300-level or above taken at ISU with a grade of C or higher.

At least 9 credits used for the minor cannot be used to meet any other department, college or university requirement for the baccalaureate degree except to satisfy the total credit requirement for graduation and to meet credit requirements in courses numbered 300 or above.

Courses for the minor cannot be taken on a pass/not-pass basis.

Course Requirements for Data Science Minor
Core Courses (9 credits)

DS 201	Introduction to Data Science (Required)	3
DS 202	Data Acquisition and Exploratory Data Analysis (Required)	3
DS 301	Applied Data Modeling and Predictive Analysis (Required)	3

* DS 301 has a prerequisite of an introductory statistics course: STAT 101, STAT 104, STAT 105, STAT 201, STAT 226, STAT 231, STAT 305, STAT 322, or STAT 330.

Electives (6 credits)		
A B E 316	Applied Numerical Methods for Agricultural and Biosystems Engineering	3
ADVRT 335	Advertising Media Planning	3
ADVRT 497J	Ad Tech	3
AGRON 270	Geospatial Technologies	3
AGRON 425	Crop and Soil Modeling	3
BCBIO 322	Introduction to Bioinformatics and Computational Biology	3
COM S 311	Introduction to the Design and Analysis of Algorithms	3
COM S 363	Introduction to Database Management Systems	3
COM S 424	Introduction to High Performance Computing	3
COM S 435	Algorithms for Large Data Sets: Theory and Practice	3
COM S 453	Privacy Preserving Algorithms and Data Security	3
COM S 474	Introduction to Machine Learning	3
C R P 251	Fundamentals of Geographic Information Systems	3
C R P 351	Intermediate Geographic Information Systems	3
C R P 452	Geographic Data Management and Planning Analysis	3
C R P 454	Fundamentals of Remote Sensing and Spatial Analysis	3
C R P 456	GIS Programming and Automation	3
CPR E 419	Software Tools for Large Scale Data Analysis	4
CPR E 426	Introduction to Parallel Algorithms and Programming	4
DS 490X	Independent Study	
ECON 371	Introductory Econometrics	4
E E 428X	Image Analysis from Machine Learning	3
ENGL 332	Visual Communication of Quantitative Information	3
FIN 450	Analytical Methods in Finance	3
I E 312	Optimization	3
I E 483	Data Mining	3
L A 558	Web Mapping and Spatial Data Visualization	3
LING 410	Language as Data	3
MATH 304	Combinatorics	3
MATH 314	Graph Theory	3
MATH 373	Introduction to Scientific Computing	3
MATH 422X	Mathematical Principles of Data Science	3
MIS 436	Introduction to Business Analytics	3
MIS 446	Advanced Business Analytics	3
MKT 368	Marketing Analytics	3
STAT 301	Intermediate Statistical Concepts and Methods	4
STAT 330	Probability and Statistics for Computer Science	3
STAT 475	Introduction to Multivariate Data Analysis	3
STAT 477	Introduction to Categorical Data Analysis	3
STAT 483	Empirical Methods for the Computational Sciences	3
STAT 486	Introduction to Statistical Computing	3
TSM 433	Precision Agriculture	3

Data Science Certificate

Purpose

The certificate in data science is intended for students studying any discipline at Iowa State and is designed to prepare them for future work with significant data science components. The data science certificate is also available to students who have already earned a Baccalaureate degree from Iowa State or elsewhere. The capstone will provide an opportunity for students to apply data science concepts to a domain problem while working in a multi-disciplinary team setting. The certificate in data science will prepare students with the technical and communication skills to enter the workforce as domain experts with data science skills.

Learning Outcomes for Data Science Certificate

After completing the certificate in data science, students will demonstrate:

- an ability to apply data science concepts, tools and technologies to data analysis pipelines,
- an understanding of ethical, legal, societal, and economic concerns in application of data science concepts,
- an ability to visualize, interpret and communicate the output of data analysis pipelines to stakeholders, and
- an ability to function on multi-disciplinary teams using concepts and tools from data science.

Requirements

The certificate in data science requires the completion of 21 credit hours, including 9 credits from the data science core, 9 credits from approved data science electives, and a three-credit data science capstone experience.

At least 9 credits must be taken in courses numbered at the 300-level or above.

At least 9 credits used for the certificate cannot be used to meet any other department, college or university requirement for the baccalaureate

degree except to satisfy the total credit requirement for graduation and to meet credit requirements in courses numbered 300 or above.

Courses for the certificate cannot be taken on a pass/not-pass basis.

Course Requirements for Data Science Certificate

Core Courses (9 credits)

DS 201	Introduction to Data Science (Required)	3
DS 202	Data Acquisition and Exploratory Data Analysis (Required)	3
DS 301	Applied Data Modeling and Predictive Analysis (Required)	3

* DS 301 has a prerequisite of an introductory statistics course: STAT 101, STAT 104, STAT 105, STAT 201, STAT 226, STAT 231, STAT 305, STAT 322, or STAT 330.

Electives (9 credits)

A B E 316	Applied Numerical Methods for Agricultural and Biosystems Engineering	3
ADVRT 335	Advertising Media Planning	3
ADVRT 497J	Ad Tech	3
BCBIO 322	Introduction to Bioinformatics and Computational Biology	3
COM S 311	Introduction to the Design and Analysis of Algorithms	3
COM S 363	Introduction to Database Management Systems	3
COM S 424	Introduction to High Performance Computing	3
COM S 435	Algorithms for Large Data Sets: Theory and Practice	3
COM S 453	Privacy Preserving Algorithms and Data Security	3
COM S 474	Introduction to Machine Learning	3
C R P 251	Fundamentals of Geographic Information Systems	3
C R P 351	Intermediate Geographic Information Systems	3
C R P 452	Geographic Data Management and Planning Analysis	3
C R P 456	GIS Programming and Automation	3
CPR E 419	Software Tools for Large Scale Data Analysis	4
CPR E 426	Introduction to Parallel Algorithms and Programming	4
ECON 371	Introductory Econometrics	4
ENGL 332	Visual Communication of Quantitative Information	3
FIN 450	Analytical Methods in Finance	3
I E 312	Optimization	3
I E 483	Data Mining	3
LING 410	Language as Data	3
MATH 304	Combinatorics	3

MATH 314	Graph Theory	3
MATH 373	Introduction to Scientific Computing (MATH 422x::Mathematical Principals of Data Science)	3
MATH 422X	Mathematical Principals of Data Science	3
MIS 436	Introduction to Business Analytics (::Mathematical Principals of Data Science)	3
MIS 446	Advanced Business Analytics	3
MKT 368	Marketing Analytics	3
STAT 301	Intermediate Statistical Concepts and Methods	4
STAT 330	Probability and Statistics for Computer Science	3
STAT 475	Introduction to Multivariate Data Analysis	3
STAT 477	Introduction to Categorical Data Analysis	3
STAT 483	Empirical Methods for the Computational Sciences	3
STAT 486	Introduction to Statistical Computing	3

Data Science capstone experience (3 credits)

DS 401	Data Science Capstone	3