# DATA ANALYTICS

# **Program Guidelines**

Global connectivity and innovative technologies generate vast amounts of information that contribute to our understanding and evaluation of nature, human behavior, institutions, society, and beyond. This explosion of evidence to present and address problems is informing major decisions in academe, government, and the private sector. Those with an ability to work with quantitative and qualitative data, big and small, to identify puzzles, consider probing questions, evaluate claims, make inferences, and posit answers will be well positioned to expand knowledge, influence policy, and to be decision makers of the future.

The major in data analytics will provide you with a solid core of mathematics and computer science, followed by specially designed data analytics courses. All of these courses are project-based, employing analytic methods, as well as ethics and interdisciplinary research skills, practiced in a variety of application domains. In addition, you will take the skills learned in the classroom and practice them in a research experience or internship in a professional setting, and then pursue a capstone project informed by this experience.

### **Mission Statement**

The Data Analytics Program prepares students to connect quantitative creative problem solving with the ability to disseminate results effectively and ethically. They learn how to acquire and handle various forms of data, to develop models that employ modern methods and algorithms to analyze and predict outcomes in data-rich environments that cover the myriad of disciplines in the liberal arts, and to communicate results through written, oral, and visual techniques to both professional and non-technical audiences. By engaging in active learning on interdisciplinary projects with an emphasis on problem solving, communication, and teamwork our students learn how to be good citizens in a rapidly changing, data-centric world. Our emphasis is on applying data analytics techniques to domain-specific data while recognizing the value of cultural knowledge and empathy that is best learned through broad exposure to the liberal arts.

# Faculty

Director: Professor Daniel Homan (Physics & Astronomy)

Associate Professors: Anthony Bonifonte, Sarah Supp

Assistant Professors: Matthew Lavin, Alexandre Scarcioffolo, Mason Shero, Zhe Wang

Associate Director. Matthew Miller

Additional Committee Members: Anjali Fernandes (Earth and Environmental Science), Zarrina Juraqulova (Economics), Matt Kretchmar (Computer Science), Nestor Matthews (Psychology), Andrew C. McCall (Biology), Matthew Neal (Mathematics), Lindsey Schwartz (Philosophy)

Other Affiliated Faculty: Jessica Bean (Economics), Paul A. Djupe (Data for Political Research), Sangeet Kumar (Communication), Ashwin Lall (Computer Science), Adam Waterbury (Mathematics), David White (Mathematics), Lina Yoo (Biology)

Academic Administrative Assistant Debbie Boissy View faculty profiles and contact information (https://denison.edu/ academics/data-analytics/contacts/)

# **Requirements Overview**

- 1. Complete Core Coursework
- 2. Complete Data Analytics Summer Experience
- 3. Select and Complete Data Analytics Domain

The detailed requirements for both BA and BS degrees are organized as follows:

# **Bachelor of Arts**

The Bachelor of Arts in Data Analytics (DA) requires a minimum of 46 credits of coursework.

1) Students must complete the following 34 credits of core coursework:

Code	Title
DA 101	Introduction to Data Analytics
CS 109	Discovering Computer Science
or CS 111	Discovering Computer Science: Scientific Data and Dynamics
or CS 112	Discovering Computer Science: Markets, Polls, and Social Networks
or CS 113	Discovering Computer Science: Physical Computing
or CS 114	Discovering Computer Science: Computing for the Social Good
MATH 135	Single Variable Calculus
or MATH 145	Multivariable Calculus
DA 200	Data Analytics Colloquium (Sophomore, 1 credit)
DA 200	Data Analytics Colloquium (Junior or Senior, 1 credit)
DA 210/CS 181	Data Systems
DA/MATH 220	Applied Statistics
DA 301	Practicum in Data Analytics
DA 351	Advanced Descriptive Methods in Data Analytics
or DA 352	Advanced Predictive Methods in Data Analytics
or DA 353	Advanced Prescriptive Methods in Data Analytics
DA 401	Seminar in Data Analytics

2) Students must complete a DA 030 (summer internship or research project). This experience must be approved by the Data Analytics Program Committee and is normally undertaken during the summer before the senior year.

3 ) Students must acquire some depth in a domain of Data Analytics. See 'Domains in Data Analytics' for more information.

# **Bachelor of Science**

Students who wish to acquire deeper methodological skills in data analytics and/or better prepare for graduate study may pursue a Bachelor of Science in Data Analytics. Students looking for added methodological depth and foundation, or to further strengthen their graduate school readiness, may also wish to pursue a minor or second major in Computer Science, Mathematics, or Applied Mathematics, or in another related quantitative field.

1) Students must complete the following 40 credits of core coursework:

Code	Title
DA 101	Introduction to Data Analytics
CS 109	Discovering Computer Science
or CS 111	Discovering Computer Science: Scientific Data and Dynamics
or CS 112	Discovering Computer Science: Markets, Polls, and Social Networks
or CS 113	Discovering Computer Science: Physical Computing
or CS 114	Discovering Computer Science: Computing for the Social Good
MATH 145	Multivariable Calculus
MATH 213	Linear Algebra and Differential Equations (recommendation: take by the end of Sophomore year.)
DA 200	Data Analytics Colloquium (once as a sophomore and once as a junior or senior, 2 credits total)
DA 210/CS 181	Data Systems
DA/MATH 220	Applied Statistics
DA 301	Practicum in Data Analytics
Complete two advanced methods in data analytics courses (DA 35X).	
DA 351	Advanced Descriptive Methods in Data Analytics
or DA 352	Advanced Predictive Methods in Data Analytics
or DA 353	Advanced Prescriptive Methods in Data Analytics
DA 401	Seminar in Data Analytics

2) Students must complete an additional methods-based elective course approved by the Data Analytics program. To avoid doublecounting elective courses, a course used to satisfy another degree program's major or minor elective requirement cannot be counted as the methods elective for the Bachelor of Science in Data Analytics. Likewise, a course that is used to satisfy a student's Data Analytics Domain cannot be counted as the methods elective for the Bachelor of Science in Data Analytics. A full list of currently offered electives that meet this requirement is maintained by the Data Analytics program. Examples include:

Code	Title
DA 271	Theory and Practice of Data Visualization
CS 271	Data Structures
CS 339	Artificial Intelligence
CS 337/MATH 415	Operations Research
CS 377	Database Systems
ECON 467	Econometrics II
MATH 420	Statistical Modeling
MATH 422	Time Series Analysis
MATH 435	Mathematical Modeling

3) Students must complete a DA 030 (summer internship or research project). This experience must be approved by the Data Analytics Program Committee and is normally undertaken during the summer before the senior year.

4) Students must acquire some depth in a domain of Data Analytics. See 'Domains in Data Analytics' for more information.

# **Domains in Data Analytics**

Students pursuing BA or BS in Data Analytics must acquire some depth in a domain of Data Analytics. They will then carry this disciplinary knowledge into their summer experience and senior seminar. Students may satisfy this requirement in one of two ways.

- 1. They may choose to take the designated set of courses from a specific department (see table below).
- 2. They may submit an individualized 3-4 course domain elective plan, which must include at least one analytics-intensive course, to be considered for approval by the Data Analytics Program Committee. A successful one-page proposal will clearly describe the student's desired learning goals and how the proposed courses together achieve these goals. The proposal should also demonstrate the feasibility of completing the proposed courses in the time remaining before graduation. Proposals must be submitted before the end of the sophomore year.

Code	Title		
Biology (4 courses)			
BIOL 210	Molecular Biology and Unicellular Life		
BIOL 220	Multicellular Life		
BIOL 230	Ecology and Evolution		
and one of the following:			
BIOL 345	Eukaryotic Cell Biology (Dr. Yoo only)		
BIOL 350	Genomics		
BIOL 356	Special Topics (Biostatistics)		
Economics (4 cou	rses)		
ECON 101	Introductory Macroeconomics		
ECON 102	Introductory Microeconomics		
ECON 302	Intermediate Microeconomic Analysis		
ECON 307	Introductory Econometrics		
Earth and Environ	mental Sciences (4 courses)		
EESC 111	Planet Earth		
Either			
EESC 234	Applied GIS for Earth and Environmental Sciences		
Or			
EESC 222 & EESC 223	Geographic Information Systems I and Geographic Information Systems II		
And one of the following:			
EESC 200	Environmental Geology		
EESC 210	Historical Geology		
EESC 211	Rocks, Minerals & Soils		
And one of the following:			
EESC 300	Geomorphology		
EESC 310	Global Biogeochemical Cycles		
EESC 311	Structural Geology		
EESC 313	Environmental Hydrology		
EESC 314	Sedimentology & Stratigraphy		
EESC 333	Stable Isotopes in the Environment		
Sustainability & Environmental Studies (4 courses)			
SES 100	Introduction to Sustainability and Environmental Studies		
SES 200	Environmental Analysis		

And one of the fo	ollowing:	
SES 215	Renewable Energy Systems	
EESC 234	Applied GIS for Earth and Environmental Sciences	
SES 222	Geographic Information Systems I	
& SES 223	and Geographic Information Systems II	
SES 240	Environmental Politics and Decision-Making	
SES 274	Ecosystem Management	
And one of the following:		
SES 256	Farmscape: Visual Immersion in the Food System	
SES 262	Environmental Dispute Resolution	
SES 264	Environmental Planning and Design	
SES 334	Sustainable Agriculture and Food Systems	
Philosophy (3 co	ourses)	
PHIL 121	Ethics: Philosophical Considerations of Morality	
or PHIL 126	Social and Political Philosophy	
PHIL 205	Logic	
PHIL 210	Philosophy of Science	
Physics (3 cours	es)	
Either:		
PHYS 121 & PHYS 122	General Physics I and General Physics II	
Or		
PHYS 125 & PHYS 126 & PHYS 127	Physics I: Quarks to Cosmos and Physics II: Mechanics, Fluids, and Heat and Physics III: Electricity, Magnetism, Waves, and Optics	
PHYS 312	Experimental Physics	
Psychology (3 co	ourses)	
PSYC 100	Introduction to Psychology	
PSYC 200	Research Methods and Statistics	
PSYC 2XX/3XX	Psychology elective (except research courses, 370, 410, 361-364, 451-452)	

# **Additional Points of Interest**

Data Analytics majors wishing to study abroad should do so in the spring semester of their junior year. Data Analytics courses are not normally taken at other institutions, although on rare occasions, a suitable substitute may be found for DA 351/2/3 - Advanced Methods for Data Analytics.

If a student uses AP credit to skip a course in their chosen domain area, that course must be replaced with a suitable substitute, determined in cooperation with the appropriate department.

### Courses

### DA 030 - Data Analytics Internship (0 Credit Hours)

This 0-credit course, summer internship, or experience, is required for all DA majors. This experience must be approved by the Data Analytics Program Committee and is normally undertaken during the summer before the senior year.

### DA 101 - Introduction to Data Analytics (4 Credit Hours)

Many of the most pressing problems in the world can be addressed with data. We are awash in data and modern citizenship demands that we become literate in how to interpret data, what assumptions and processes are necessary to analyze data, as well as how we might participate in generating our own analyses and presentations of data. Consequently, data analytics is an emerging field with skills applicable to a wide variety of disciplines. This course introduces analysis, computation, and presentation concerns through the investigation of data driven puzzles in wide array of fields – political, economic, historical, social, biological, and others. No previous experience is required.

DA 199 - Introductory Topics in Data Analytics (1-4 Credit Hours) A general category used only in the evaluation of transfer credit.

### DA 200 - Data Analytics Colloquium (1 Credit Hour)

The Data Analytics colloquium involves three central learning components. 1) regular engagement with guest presentations and community activities in data analytics, 2) group discussion featuring critical analysis and connection of themes found in the guest presentations and in related data analytics topics, and 3) preparation and refinement of professional communication skills necessary for the required internship component of the data analytics major. This course provides an opportunity for students to connect on data analytics ideas and applications, using a range of perspectives that may or may not be normally encountered in a traditional course. Students will develop the knowledge, skills, and methods they need to progress to more advanced learning, while also creating bridges with members of the data analytics community within and outside of Denison. The course must be taken twice by majors: once as a sophomore, and again as either a junior or senior.

Prerequisite(s): DA 101 (may be taken concurrently).

### DA 210 - Data Systems (4 Credit Hours)

This course provides a broad perspective on the access, structure, storage, and representation of data. It encompasses traditional database systems, but extends to other structured and unstructured repositories of data and their access/acquisition in a client-server model of Internet computing. Also developed are an understanding of data representations amenable to structured analysis, and the algorithms and techniques for transforming and restructuring data to allow such analysis. **Prerequisite(s):** CS 109 or CS 111 or CS 112 or CS 113 or CS 114. **Crosslisting:** CS 181.

### DA 220 - Applied Statistics (4 Credit Hours)

Statistics is the science of reasoning from data. This course will introduce the fundamental concepts and methods of statistics using calculus-based probability. Topics include a basic study of probability models, sampling distributions, confidence intervals, hypothesis testing, categorical data analysis, ANOVA, multivariate regression analysis, logistic regression, and other statistical methods. Scopes of conclusion, model building and validation principles, and common methodological errors are stressed throughout.

**Prerequisite(s):** Either MATH 145 or both MATH 135 and DA 101. **Crosslisting:** MATH 220.

#### DA 245 - Topics in Data Analytics (4 Credit Hours)

This course provides a venue to explore intermediate topics in Data. Topics courses will vary in content according to the interests of the faculty offering the course and possibly to introduce new classes into the curriculum. Courses at this level should be appropriate for students with introductory work in DA and/or related courses.

### DA 271 - Theory and Practice of Data Visualization (4 Credit Hours)

Data visualization turns data and analysis into something people can see, and something they can comprehend. The practice of data visualization is built on the science of perception and the art of visual metaphors. While data visualization is a skillset demanded of any role involving data and analytics, there is also a field of study and discipline dedicated to the design and creation of graphical representations of data. This course introduces the discipline of data visualization, design principles and theory, and the way data visualization is used in a variety of fields. As part of this course, you will create and refine your own portfolio of dashboards and infographics, and learn to evaluate data visualization through workshops involving peer-to-peer feedback. **Prerequisite(s):** DA 101.

### DA 272 - Ethics of Data and Information (4 Credit Hours)

This course is a problem-driven, technically informed engagement with the ethics of data and information as well as an investigation of the moral dimensions of collecting, analyzing, and protecting data. It aims to equip students with the ethical frameworks and philosophical tools necessary to effectively engage with the urgent questions posed by data-driven technology in its various forms. Students will hone their understanding of the ethics of surveillance, scientific research, algorithmic bias, and policy decision-making. We will also investigate how familiar moral notions like privacy, property, fairness, and equality are challenged or illuminated by computational tools and the advent of novel possibilities for data collection and analysis. Projects in the course will seek to put into practice the ethical principles and moral theories in hopes of tackling data-driven decisions prudently and permissibly.

#### **DA 299 - Intermediate Topics in Data Analytics (1-4 Credit Hours)** A general category used only in the evaluation of transfer credit.

#### DA 301 - Practicum in Data Analytics (4 Credit Hours)

Utilizing Denison as a model of society, this practicum will explore questions of collective import through the analysis of new and existing sources of data. A problem-driven approach will lead to the acquisition of new, appropriate data analytic skills, set in an ethical context that carefully considers the implications of data display and policy recommendations on community members. A significant component of the course is working in teams to collect and analyze new data to address a puzzle or problem for a real client. Groups or organizations that serve as clients may come from the campus community, local non-profits, or businesses and groups across the region or country. The practicum also develops exposure to policymaking, implementing data driven insights, program management theory, interacting with leaders and professionals, and developing presentation skills appropriate for professional communication with the public. Though a significant learning opportunity itself, this course should also be seen as a prelude to a community internship or research experience in the post-junior year summer. Students should be aware that some off-campus travel may be necessary to meet with specific clients as necessary. Final presentations to the client, in lieu of a scheduled exam, requires flexibility and scheduling outside of the exam schedule.

Prerequisite(s): DA 101, DA 210 and DA 220, or consent of instructor.

#### DA 345 - Advanced Topics in Data Analytics (4 Credit Hours)

This course provides a venue to explore advanced topics in Data. Topics courses will vary in content according to the interests of the faculty offering the course and possibly to introduce new classes into the curriculum. Courses at this level should be appropriate for students with significant work in DA and/or related courses and may require other prerequisites.

#### DA 350 - Advanced Methods for Data Analytics (4 Credit Hours)

This course is designed to develop students' understanding of the cutting-edge methods and algorithms of data analytics and how they can be used to answer questions about real-world problems. These methods can learn from existing data to make and evaluate predictions. The course will examine both supervised and unsupervised methods and will include topics such as dimensionality reduction, machine learning techniques, handling missing data, and prescriptive analytics. **Prerequisite(s):** DA 210 and DA 220 or consent of instructor.

# DA 351 - Advanced Descriptive Methods in Data Analytics (4 Credit Hours)

Advanced Descriptive Methods (DA 351), in parallel with DA 352 and 353, is designed to develop students' understanding of the cutting-edge methods and algorithms of data analytics and how they can be used to answer questions about real-world problems. While all advanced methods for Data Analytics can be applied in a variety of capacities, descriptive analytics emphasizes using natural language processing (NLP) methods to work with text as data, modeling for interpretability, and designing and deploying computer vision systems. In DA 351 students will examine both supervised and unsupervised methods, including topics such as advanced regression, K nearest neighbors, hierarchical clustering, ranked cosine similarity, and deep learning.

Prerequisite(s): DA 210 or CS 181 and MATH 220 or DA 220.

### DA 352 - Advanced Predictive Methods in Data Analytics (4 Credit Hours) Advanced Predictive Methods (DA 352), in parallel with DA 351 and 353, is designed to develop students' understanding of the cutting-edge methods and algorithms of data analytics and how they can be used to answer questions about real-world problems. While all advanced methods for Data Analytics can be applied in a variety of capacities, predictive methods emphasize learning from existing data to make predictions about new data. In DA 352 students will examine both supervised and unsupervised methods and will include topics such as clustering, classification, and network analysis.

Prerequisite(s): DA 210 or CS 181 and DA 220 or MATH 220.

# DA 353 - Advanced Prescriptive Methods in Data Analytics (4 Credit Hours)

Advanced Prescriptive Methods (DA 353), in parallel with DA 351 and 352, is designed to develop students' understanding of the cutting-edge methods and algorithms of data analytics and how they can be used to answer questions about real-world problems. While all advanced methods for Data Analytics can be applied in a variety of capacities, prescriptive analytics emphasizes formulating decision criteria, using data to identify optimal actions, and balancing benefits and tradeoffs of different solutions. In DA 353 students will examine both supervised and unsupervised methods and will include topics such as optimization and linear programming, reinforcement learning, simulation, and decision analysis.

Prerequisite(s): DA 210/CS 181; DA 220/MATH 220.

#### DA 361 - Directed Study (1-4 Credit Hours)

A student in good standing may work intensively in areas of special interest under the Directed Study plan. A Directed Study is appropriate when, under the guidance of a faculty member, a student wants to explore a subject more fully than is possible in a regular course or to study a subject not covered in the regular curriculum. A Directed Study should not normally duplicate a course that is regularly offered. Directed Studies are normally taken for 3 or 4 credits. A one-semester Directed Studies may not be used to fulfill General Education requirements.

### DA 362 - Directed Study (1-4 Credit Hours)

A student in good standing may work intensively in areas of special interest under the Directed Study plan. A Directed Study is appropriate when, under the guidance of a faculty member, a student wants to explore a subject more fully than is possible in a regular course or to study a subject not covered in the regular curriculum. A Directed Study should not normally duplicate a course that is regularly offered. Directed Studies are normally taken for 3 or 4 credits. A one-semester Directed Studies may not be used to fulfill General Education requirements.

#### DA 363 - Independent Study (1-4 Credit Hours)

Independent Study engages a student in the pursuit of clearly defined goals. In this effort a student may employ skills and information developed in previous course experiences or may develop some mastery of new knowledge or skills. A proposal for an Independent Study project must be approved in advance by the faculty member who agrees to serve as the project advisor. Note: Independent Studies may not be used to fulfill General Education requirements.

#### DA 364 - Independent Study (1-4 Credit Hours)

Independent Study engages a student in the pursuit of clearly defined goals. In this effort a student may employ skills and information developed in previous course experiences or may develop some mastery of new knowledge or skills. A proposal for an Independent Study project must be approved in advance by the faculty member who agrees to serve as the project advisor. Note: Independent Studies may not be used to fulfill General Education requirements.

#### DA 399 - Advanced Topics in Data Analytics (1-4 Credit Hours)

A general category used only in the evaluation of transfer credit.

#### DA 401 - Seminar in Data Analytics (4 Credit Hours)

This is a capstone seminar for the Data Analytics major in which students work on independent research projects in a collaborative seminar setting. Problems may derive from internship experiences, courses of study at Denison, or another source subject to instructor approval. Heavy emphasis will be placed on providing ongoing research reports and collective problem solving and review.

#### DA 451 - Senior Research (4 Credit Hours)

Students may enroll in Senior Research in their final year at Denison. Normally, Senior Research requires a major thesis, report, or project in the student's field of concentration and carries eight semester-hours of credit for the year. Typically, a final grade for a year-long Senior Research will not be assigned until the completion of the year-long Senior Research at the end of the second semester. In which case, the first semester Senior Research grade will remain "in progress" (PR) until the completion of the second semester Senior Research. Each semester of Senior Research is limited to a maximum of 4 credit hours. Note: Senior Research may not be used to fulfill General Education requirements.

#### DA 452 - Senior Research (4 Credit Hours)

Students may enroll in Senior Research in their final year at Denison. Normally, Senior Research requires a major thesis, report, or project in the student's field of concentration and carries eight semester-hours of credit for the year. Typically, a final grade for a year-long Senior Research will not be assigned until the completion of the year-long Senior Research at the end of the second semester. In which case, the first semester Senior Research grade will remain "in progress" (PR) until the completion of the second semester Senior Research. Each semester of Senior Research is limited to a maximum of 4 credit hours. Note: Senior Research may not be used to fulfill General Education requirements.