BOARD OF HIGHER EDUCATION
REQUEST FOR BOARD ACTION

NO: BHE 25-19

BOARD DATE: October 22, 2024

APPROVAL OF LETTER OF INTENT OF UMASS LOWELL TO AWARD THE BACHELOR OF SCIENCE IN DATA SCIENCE AND AUTHORIZATION FOR FAST TRACK REVIEW

MOVED: The Board of Higher Education (BHE) has evaluated the Letter of Intent of **UMASS Lowell** to award the **Bachelor of Science in Data Science** and has determined that the proposal aligns with BHE criteria. Accordingly, the BHE authorizes the Commissioner to review the program and to make a final determination on degree granting authority pursuant to the Fast-Track review protocol.

VOTED: Motion adopted by BHE on 10/22/2024.

Authority: Massachusetts General Laws Chapter 15A, Section 9(b); AAC 18-40

Contact: Richard Riccardi, Sc.D., Deputy Commissioner for Academic Affairs and Student Success

BOARD OF HIGHER EDUCATION
October 22, 2024
UMASS Lowell
Letter of Intent
Bachelor of Science in Data Science

DEGREE TITLE ABSTRACT ON INTENT AND MISSION OF PROGRAM

UMass Lowell intends that the proposed degree for a Bachelor of Science in Data Science will address the growing need for data scientists which has been fueled by the exponential growth in data. The proposed degree program will provide a well-rounded and comprehensive education, with a curriculum offering a broad education in Data Science combined with a solid foundation in science and engineering fundamentals. Designed to be more than a typically modified Mathematics or Computer Science curriculum, the proposed degree program is composed of a new core developed with a systematic and holistic approach from theory to applications with sufficient hands-on training. The proposed curriculum provides a balance of art and science that offers the student a complete education through general educations on writing, arts and humanities and social sciences with emphases on communication skills and principles of diversity and ethics, and math and natural sciences with labs; and through a rich set of rigorous core courses on theoretical knowledge and programming skills in Data Science that every student must take, a pair of project courses, sufficient technical and free electives, and a capstone project. Given the demand for these students, the proposed degree program will provide students with excellent prospects when entering a thriving job market.

The proposed Bachelor of Science in Data Science program was approved by UMass Lowell's Board of Trustees on April 1, 2024. The LOI was circulated on June 14, 2024. One comment was received supportive of the proposal with a curricular suggestion that was forwarded to the institution.

A. ALIGNMENT WITH MASSACHUSETTS GOALS FOR HIGHER EDUCATION

Address Gaps in Opportunity and Achievement in Alignment with Campus-Wide Goals

The strong demand for data scientists has been driven by the explosive growth in the amount of data available, in applications across multiple domains in different disciplines, in appreciations of values of

processed data that lead to making better decisions, and in the advancement of Graphics Processing Unit, General Artificial Intelligence technologies, and large language models that lead to substantial improvement on the capability of processing large amount of data. Noted in Harvard Business Review and other relevant trade magazines time and again, this trend will continue to grow at a speed faster than any other fields.

Today, data scientists are needed in virtually every sector, private and public, from agriculture to industry, from service to entertainment, from education to healthcare, and from civil activities to military operations. These include manufacturing, construction, transportation, warehousing, communication, science, medicine, retail sales, marketing, finance, insurance, teaching, research, government, security, and law enforcement, among other areas. However, none of the existing degree programs at UMass Lowell specifically prepare students to meet this demand. To fill this gap calls for a new academic degree program, and in particular, a Bachelor of Science degree program in Data Science. It is time to recognize this emerging academic discipline.

Data Science consists of methodologies and tools, built on computing technologies, to deal with massive data arising in a variety of applications, as well as practical domain expertise to supply decision-making knowledge. While related to data mining and machine learning taught in the BS in Computer Science degree curriculum at UMass Lowell, Data Science is much broader in scope. A robust Data Science degree program is much more than just shuffling existing courses with a few new courses added to the existing Computer Science curriculum.

Rather, Data Science covers the knowledge and skills of processing massive data of various types. This is a major shift from a data-insensitive Computer Science curriculum. Therefore, while it is essential for Data Science students to learn how to write computer programs, it is important for them to learn how to use computing technologies to wrangle, manage, model, process, and analyze data. It is also important for Data Science students to master the state-of-the-art concepts and tools in Computer Science, Mathematics, and Statistics, but not necessarily to learn how to build the tools themselves. Students must also have the ability to apply theoretical knowledge and practical skills in solving data-driven real-world problems and possess collaboration and communication skills.

UMASS Lowell has received an increasing number of inquiries from high school seniors, parents, current students, and transferred students about the opportunity for pursuing a bachelor's degree in data-centric computing. These students, while interested in computing technologies and programming, may not be necessarily into the standard computer science curriculum that includes computing theory and system-level programming. This makes the proposed degree program in Data Science, rather than a degree in Computer Science, Statistics, or other disciplines more appropriate for this group of students to achieve their career goals.

Realizing all of these, the Faculty Senate at UMass Lowell approved and authorized, on November 20, 2020, the Department of Computer Science (now Richard Miner School of Computer and Information Sciences) at the Kennedy College of Sciences to develop a Bachelor of Science in Data Science degree program. The goal is to produce qualified data scientists armed with sufficient programming skills, rigorous theoretical foundations in data modeling and analysis, and solid understandings of modern machine-learning and deep-learning technologies with adequate hands-on experiences in chosen application areas.

Student success has been and will always be central at UMass Lowell and what makes UMass Lowell distinctive. UMass Lowell believes that the promise of a public education is to provide an accessible, affordable, and transformational educational experience well-anchored by support, connections, and opportunities. Furthermore, UMass Lowell strongly believes that none of this happens without excellent teaching. The proposed degree program aligns well with this educational goal and mission.

Program or Department Supports to Ensure Student Retention and Completion

The proposed degree program will be housed in and managed by the Richard Miner School of Computer and Information Sciences (CIS). As such, the new proposed degree program will have the same checks, balances, advising, mentoring and other support structures already in place for the long-standing B.S. in Computer Science, which is the largest undergraduate program at UMass Lowell. The Miner School's

support systems have resulted in high persistence rates and training and skills that for decades have been in high demand in industry and highly recognized in academia.

The Undergraduate Coordinator provides leadership and vision for all undergraduate advising and works closely with the department undergraduate committee on student success issues. Students are required to meet with their assigned professional academic or faculty advisor every semester to discuss their overall progress, academic challenges, and plan their schedule before registering for the upcoming semester. These meetings are designed to ensure students adhere to the official degree requirements and stay on track for the typical 4-year graduation. Students also received mentoring and guidance on internship and co-op opportunities, career options, graduate schools, and more. CIS undergraduate also has access to extensive campus resources including the Centers for Learning and Student Success, Career & Co-Op Center, Disability Services, and more.

The Minor School already offers a Data Science concentration for the BS in Computer Science. Thus, the current CIS faculty have accumulated substantial experiences in undergraduate teaching in this area over the years, with a number of faculty members currently doing data-driven research and teaching data-driven courses at the undergraduate and graduate levels.

The Kennedy College of Sciences and UMass Lowell administration is committed to the success of the proposed degree program, providing leaderships and necessary supports, including classrooms, lab space, and new faculty lines. The faculty at the Miner School Computer & Information Sciences is committed to teaching some of the courses in the proposed curriculum.

Alliances and Partnerships with PK-12, Other IHE's, Community Employers

The Miner School already has a Data Science Advisory Group, and this group will help ensure the proposed curriculum stays current, connect students to potential co-op opportunities and employers, and provide problems for capstone projects. Current members of the advisory group include the following:

- Hoifung Poon, PhD, Senior Director, Biomedical NLP, Microsoft Research
- Cassie Kozyrkov, PhD, Chief Decision Scientist, Google
- Michael Salem, PhD, Director, Data Science, Facebook
- James Allan, PhD, College of Information and Computer Sciences, UMass Amherst

- James Cimino, MD, Director of UAB Informatics Institute, University of Alabama at Birmingham

The Miner School also has extensive corporate partners engaged in philanthropic support of CS activities. This includes Red Hat and Teradyne support for SoarCS, Schneider Electric sponsorship of undergrad design projects, and Amazon's gifts to support the research of Anna Rumshisky (Amazon Alexa) and Holly Yanco, Maru Cabrera, and Reza Ahmadzadeh (Amazon Robotics).

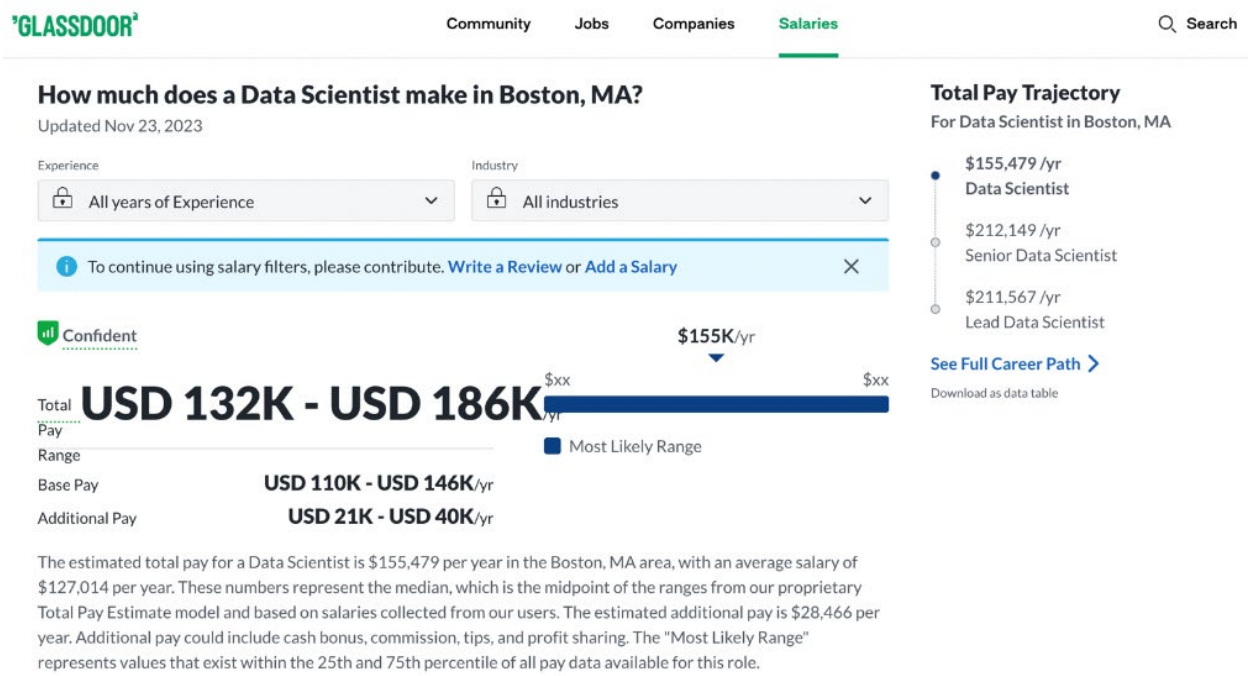
Computer Science faculty and students have been involved in various alliances and partnerships with area high schools – most prominent of which is Lowell High. Computer Science students are also involved in the UTeach STEM teaching program, which includes Digital Literacy and Computer Science Licensure. The University is currently working with Reading High School to start an Innovation Pathways Program with CS beginning in Fall 2024.

Finally, the Miner School has strong ties with various community colleges including Bunker Hill, Northern Essex, and especially Middlesex Community College (MCCS) and works hard to align curricula and streamline the transfer process for these students. In addition, UML various bridge programs and research engagement opportunities for community college students and is currently in the process of working with MCC on a $5M S-STEM Scholarship Program application to the NSF.

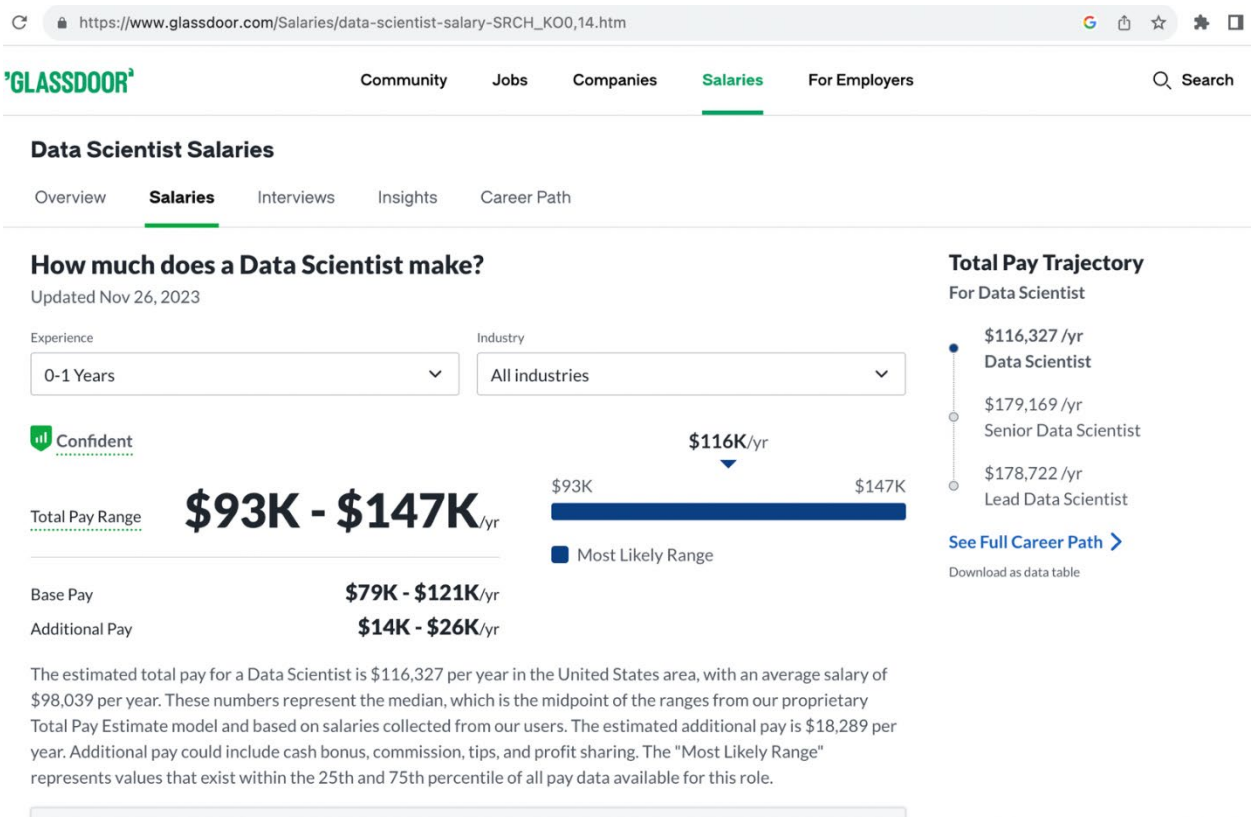
Relationship to MassHire Regional Blueprints

The state of Massachusetts, particularly in the greater Boston area, is a central location for Data Science opportunities. Jobs for Data Scientists offer consistently high salaries in Massachusetts and other states in the US.

- According to Glassdoor, Data Science jobs in the Boston area have a pay range from $132K to $186K a year. The following screen shot is extracted from Glassdoor (November 23, 2023), How Much Does a Data Scientist Make in Boston, MA? Retrieved from URL https://www.glassdoor.com/Salaries/boston-data-scientist-salary-SRCH_IL.0,6_IM109_KO7,21.htm :



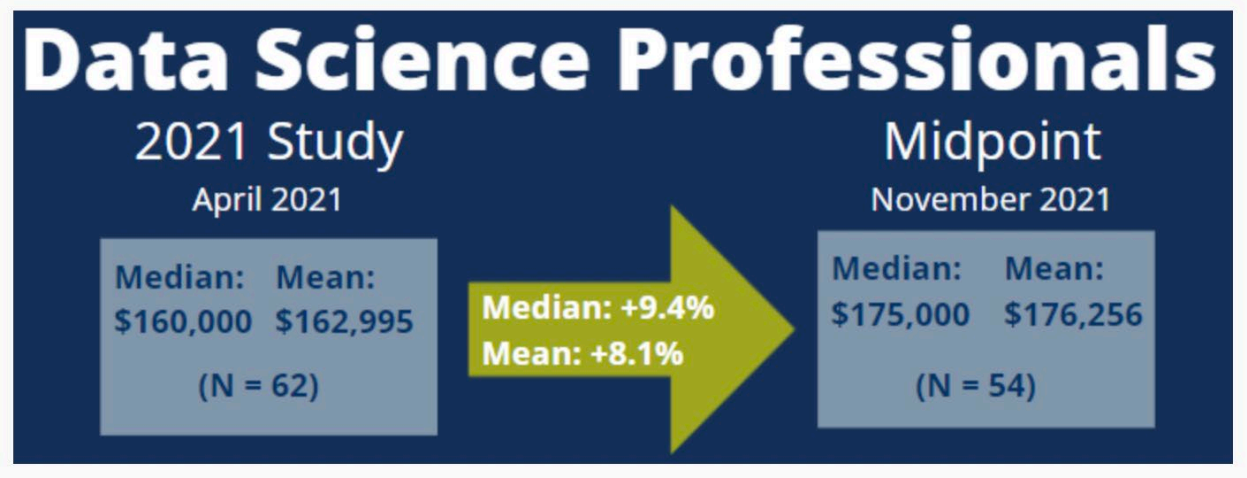
- According to Glassdoor, data science jobs in the US with 0-1 year of experience have a pay range from $93K to $147K a year. The following screen shot is extracted from Glassdoor (November 26, 2023), How Much Does a Data Scientist Make? Retrieved from URL https://www.glassdoor.com/Salaries/data-scientist-salary-SRCH_KO0,14.htm:



- According to a 2023 survey conducted by Burtch Works (January 31, 2023), Survey Results: 2023 Data Science, Analytics & Data Engineering Hiring in Q1/Q2, the demand for data scientists remains high. The following passage is extracted from URL https://burtchworks.com/industry-insights/survey-results-2023-data-science-analytics-data-engineering-hiring-in-q1-q2:

"[…] one thing remains clear - the demand for data scientists, analytics professionals, and data engineers remains high as organizations continue to prioritize a data-driven culture and digital transformation efforts. It is also worth noting that the data science, analytics and data engineering fields have been relatively resilient to the impacts of economic downturns, and it is industry agnostic."

- According to a Burtch Works study, data science salaries are on the rise. For example, the following figure is extracted from Burtch Works (February 3, 2022), Data Science & Analytics Salaries are on the Rise, retrieved from URL https://burtchworks.com/industry-insights/data-science-analytics-salaries-are-on-the-rise:



• According to Harvard Business Review, the data science job will continue to grow, and the field is projected to experience more growth than almost any other field by 2029. The following passage is extracted from Davenport, Thomas H and Patil, DJ (July 15, 2022), Is Data Scientist Still the Sexiest Job of the 21st Century? Harvard Business Review, retrieved from URL https://hbr.org/2022/07/is-data-scientist-still-the-sexiest-job-of-the-21st-century:

"A decade later, the [data science] job is more in demand than ever with employers and recruiters. AI is increasingly popular in business, and companies of all sizes and locations feel they need data scientists to develop AI models. By 2019, postings for data scientists on Indeed had risen by 256%, and the U.S. Bureau of Labor Statistics, predicts data science will see more growth than almost any other field between now and 2029. The sought-after job is generally paid quite well; the median salary for an experienced data scientist in California is approaching $200,000."

Duplication

Neither UMass Amherst nor UMass Boston offer an undergraduate degree program in Data Science. UMass Dartmouth offers a BS degree in Data Science, jointly with its Computer Science Department and Mathematics Department. It covers topics such as data visualization and matrix methods for data mining, as well as more traditional courses in computer and information science and mathematics.

Tufts University offers a BS degree program in Data Science, offered to students in the School of Engineering, with a concentration on applying computing to scientific and engineering analysis and problem solving. Their BSDS is designed both as a standalone major and a double major option for those students in Engineering who wish to add data science to an existing engineering major. Students adding

Data Science as a second major must fulfill all of the requirements on the degree sheet, subject to double-counting rules. Tufts' approach is engineering oriented.

Northeastern University offers a BS degree program in Data Science that combines computer science, information science, mathematics, statistics, and probability theory into an integrated curriculum that prepares students for careers or graduate studies in big data analysis, data science, and data analytics.

The proposed degree program is more in line with Northeastern University's program. Instead of adding a few extra courses on top of the existing Computer Science and Mathematics curricula, a new core with a systematic and holistic approach from theory to applications with sufficient hands-on training is proposed. UMass Lowell believes that it is crucial to have a program of this kind in a public university in Massachusetts to better serve Massachusetts students and the regional industry, fulfilling its mission and filling this void.

Innovative Approaches to Teaching and Learning

The proposed degree program has a focus on hands-on training on solving real-word problems using computer technologies. For example, the Miner School of Computer and Information Science has recently acquired a number of high-end GPU servers that will be used in teaching high-level courses in the proposed degree program.

B. ALIGNMENT WITH CAMPUS STRATEGIC PLAN AND MISSION

As mentioned in the previous narratives, the proposed degree program fits into the mission and vision of UMass Lowell as a public institution serving the Commonwealth of Massachusetts by providing its students with an affordable and innovative path to the regional industries that serve its residents. The proposed degree program will produce qualified data scientists entering the job market with the foundational skills necessary to be successful in the workforce. At the core of UMass Lowell's strategic plan is student success and is what distinguishes UMass Lowell from its peers. As stated previously, UMass Lowell believes that the promise of a public education is to provide an accessible, affordable, and transformational educational experience well-anchored by support, connections, and opportunities. The proposed degree program aligns well with its campus strategic plan and overall mission.

Goals and Objectives (Form B)

The Miner School of Computer and Information Sciences at UMass Lowell strives to be a department of choice for students and is actively repositioning itself. It offers focused BS, MS, and PhD degree programs to provide graduates of immediate value to the community. The proposed degree program has the following educational goals and objectives.

Educational Objectives

1) Be established and recognized as a valued professional and effective communicator in industries related to data science and computing technologies.

   To achieve this objective, the proposed curriculum is designed to provide a solid education to students through general educations on writing, arts and humanities and social sciences with emphases on communication skills and principles of diversity and ethics, and math and natural sciences with labs; and through a rich set of rigorous core courses on theoretical knowledge and programming skills in Data Science that every student must take, a pair of project courses, sufficient technical and free electives, and a capstone project.

   Most Data Science core courses at the higher levels in the proposed curriculum have a component of written and oral communications, where students are required to write project reports and present their results in class. A mid-level Data Science core course required to take by every student and transfer student has a dedicated topic on Data Science ethics to completement the general education on the topic.

   The pair of project courses will be chosen by students in a sub-area of Data Science from a large pool of courses. Students will receive intensive training through the project sequence in a sub-area of their choice. This pool of courses offers course dealing with scientific data, text data, image and video data in various applications, as well as in public health and other applications.

   Each student will have three technical electives and three free electives, making it possible for students to explore broader interests and go deeper in one or more chosen sub-areas of Data

Science in connection to various domain applications. Students may also use these slots of electives to pursue a minor in other academic disciplines, or a double major in a related discipline, to become a versatile data scientist.

The capstone project is an integrated training and final assessment of knowledge and skills possessed by students to develop, implement, and evaluate solutions for tackling real-word data-centric problems under the guidance of professionals in companies and organizations outside UMass Lowell, or in different departments on campus, jointly directed under Data Science faculty. Students will receive in-depth trainings on problem-solving techniques in practice by integrating what they learn in the classroom settings, on writing professional reports, and on making presentations to the general audience, peers, and authorities—in this case a school capstone-project committee.

2) Practice their profession in a collaborative, team-oriented manner that embraces the multidisciplinary and multicultural environment of today's business world.

To achieve this objective, team projects in classes will be offered as well as in the capstone project.

3) Engage in lifelong learning and professional development via post graduate education and participation in professional organizations.

To achieve this objective, students will be prepared, through the general education and in-depth, versatile training in Data Science, to tackle new problems, learn new knowledge, and master new skills needed in the careers they pursue.

4) Function as a responsible member of society with willingness to mentor fellow employees and an understanding of the ethical, social, and economic impact of their work in a global context.

To achieve this objective, students will be educated through courses with a dedicated component on ethics and diversity in the general setting, through teamwork in the classroom

setting, and through the capstone project in the professional setting.

Educational Outcomes

The proposed degree program is designed to provide a well-rounded and comprehensive education, with a curriculum offering a broad education in Data Science combined with a solid foundation in science and engineering fundamentals. In addition, the program has emphasized interaction and communication skills.

At graduation, Data Science students are expected to possess the following skills:

1) The ability to apply computing tools and data modeling methods to create application software, from analysis to design to implementation and testing.

   Students obtain this ability through DATA.1010 + DATA.1011L (or COMP.1010 + COMP1030L), DATA.1020 + DATA.1021L (or COMP.1020 + COMP1040L), DATA.2010, DATA.2012, DATA.2101, DATA.2201. Each data science course, including linear algebra and those with an emphasis on theoretical foundations, has a substantial programming component to train students to become an efficient and effective application program coder.

2) A strong foundation in data processing, data modeling, and data management, as well as the mathematics, statistics, and science that underlie the discipline.

   Students obtain this set of knowledge through DATA.2251, DATA.3102, DATA.3210, DATA.3220, DATA3221, MATH.1310, MATH.1320, MATH.2190, MATH.3850 (statistics), and MATH.3860 (statistics).

3) A deeper understanding of one or more areas of data science of their choosing.

   Students obtain this knowledge through (select two courses in the same group) Group I: DATA.3410, DATA,4430, DATA.4701, DATA.4702; Group II: DATA.4201, DATA.4501; Group III: COMP.4270, COMP.4280, COMP.4230.

4) A solid understanding of one or more data-driven domain application areas in other disciplines.

Students obtain this knowledge through, for example, ECON.2110, ECON.2120, ECON.4070; ENVI.3010, ATMO.4130, ATMO.4220, ATMO.4970, ENVI.4970.

5) Good written and oral communications skills.

Students obtain these skills through general education on writing and other courses with an emphasis on written and oral communications offered by the arts and humanity departments and the social science departments at UMass Lowell, as well as data science courses with a requirement of writing project reports and making presentations such as DATA.4430 and DATA.4900.

6) The ability to work effectively in teams, as jobs in data science require large groups of people across disciplines to work together.

Students obtain this ability through, for example, DATA.2012, DATA.3102, and DATA.4990.

7) An appreciation of the societal consequences of technology, data, and of the ethical issues that arise with recent technologies.

Students obtain this appreciation through, for example, general education on courses with an emphasis on ethics and diversity offered by the arts and humanity departments and the social science departments at UMass Lowell, and DATA.2012 and DATA.4900.

8) The knowledge and skills necessary to obtain employment after graduation or to continue their study of data science or related fields in graduate school.

Students obtain these sets of knowledge and skills through all the courses offered in the curriculum, where DATA.4900 Capstone Project is particularly designed to train and assess

students' knowledge and skills for employment.

Assessment

Assessment of student success will be based on the following evaluation:

1) Homework assignments
2) Classroom participation and discussion
3) Lab work
4) Coding projects
5) Quizzes and exams

Expected Placement Rate: At least 90%.

C. ALIGNMENT WITH OPERATIONAL AND FINANCIAL OBJECTIVES OF INSTITUTION

UMass Lowell's administration anticipates a positive impact on enrollment in other programs. For example, some students enrolled in the BS in Data Science program will switch to the BS in Computer Science program if they are more interested in system-level programing and developing tools for Data Scientists. In addition, based on transition rates for current Computer Science students, the administration expects approximately 30-35% of the students who start in the major will transition to other degree programs within the college and across the campus including business, mathematics, engineering, etc.

Enrollment Projections (Form C)

In Year 1 of the proposed degree program, UMass Lowell projects an initial cohort of 60 full-time students. Over the following four years, new student enrollment is projected to increase by 10% each year to a high of 86 students in Year 5. Factoring in a relatively modest retention rate in the major coupled with

continued recruitment of new students results in program growth of almost 4 times the initial cohort over the five years of the projections (220 students).

Resources and Financial Statement of Estimated Net Impact on Institution
(Form D, Appendices)

The proposed degree program will require the following resources:

Additional Faculty and Staff

All existing courses in Computer Science (courses with a prefix of COMP), Mathematics (courses with a prefix of MATH), and other academic departments are covered by existing faculty and supporting staff.

To cover the proposed Data Science courses and support the program, five new faculty members and one staff member will be required to start the program. A number of current Computer Science faculty members will also teach Data Science courses on the part-time basics. The staff member will assist administrative work and coordinate Capstone Projects with companies, off-campus organizations, and different departments on campus.

For convenience, the requested five new faculty positions are named by F1, F2, F3, F4, F5 as placeholders. Course offering and staffing in Year 4 will be the norm for future years, where F1 is non-tenure-track, and F2—F5 are tenure-track.

Year	Status	Fall	Spring	Staffing
1	Freshman	DATA.1010 DATA.1011L	DATA.1010 DATA.1011L DATA.1020 DATA.1021L	Covered by F1 & 1 TA (TAs cover Labs)
2	Freshman	DATA.1010 DATA.1011L DATA.1020 DATA.1021L	DATA.1010 DATA.1011L DATA.1020 DATA.1021L	Covered by F1 & 1 TA (TAs cover Labs)
	Sophomore	DATA.2010 DATA.2251	DATA.2010 DATA.2251 DATA.2101 DATA.2051	Covered by F1, F2 & 2 TAs (TAs cover Labs)

3	Freshman	DATA.1010 DATA.1011L DATA.1020 DATA.1021L	DATA.1010 DATA.1011L DATA.1020 DATA.1021L	Covered by F1 & 1 TA (TAs cover Labs)
	Sophomore	DATA.2010 DATA.2251 DATA.2101 DATA.2051	DATA.2010 DATA.2251 DATA.2101 DATA.2051	Covered by F1, F2, existing CS faculty & 2 TAs (TAs cover Labs)
	Junior	DATA.2012 DATA.3210	DATA.2012 DATA.3210 DATA.3102 DATA.3220	Covered by F3, F4, existing CS faculty & 3 TAs
4	Freshman	DATA.1010 DATA.1011L DATA.1020 DATA.1021L	DATA.1010 DATA.1011L DATA.1020 DATA.1021L	Covered by F1 & 1 TA (TAs cover Labs)
	Sophomore	DATA.2010 DATA.2251 DATA.2101 DATA.2051	DATA.2010 DATA.2251 DATA.2101 DATA.2051	Covered by F1, F2, existing CS faculty & 2 TAs (TAs cover Labs)
	Junior	DATA.2012 DATA.3210 DATA.3102 DATA.3220	DATA.2012 DATA.3210 DATA.3102 DATA.3220	Covered by F3, F4, existing CS faculty, & 3 TAs
	Senior	DATA.3221 Project Pair 1	DATA.3221 Project Pair 1 Project Pair 2 DATA.4900	Covered by F5, existing CS faculty, & 2TAs

Office Space

Office space will be required for F1 in Year 1, additional office space for F2 in Year 2, additional office spaces for F3 and F4 in Year 3, and additional office space for F5 in Year 4. The staff member may use the existing office space for staff in the school. No more faculty space is needed unless increasing enrollment calls for more faculty members to support the program.

Classroom, Lab Space, Equipment

The proposed degree program will utilize the existing classroom and lab space and equipment provided by the University and School to start the program.

Startup & Maintenance

Please see Form D for startup and maintenance costs.

Anticipated Net Financial Impact

The anticipated net financial net impact of the proposed degree program, excluding space cost, is listed below:

- Year 1: net income = tuition/fees income – expenses = 679K – 251K = 428K
- Year 2: net income = tuition/fees income – expenses = 1.405M – 421K = 984M
- Year 3: net income = tuition/fees income – expenses = 2.170M – 706K = 1.464M
- Year 4: net income = tuition/fees income – expenses = 3.021M – 861K = 2.160M
- Year 5: net income = tuition/fees income – expenses = 3.837M – 1.036M = 2.801M

The net financial impact becomes stable from Year 5.

STAFF REVIEW AND VALIDATION

Staff thoroughly reviewed the **LOI** proposing full degree granting authority for the **Bachelor of Science in Data Science** program submitted by **UMASS Lowell**. Staff validate that the **LOI** includes all data required by the Massachusetts Board of Higher Education. Staff recommendation is for BHE authorization for the Commissioner to review the program pursuant to the Fast-Track review protocol.

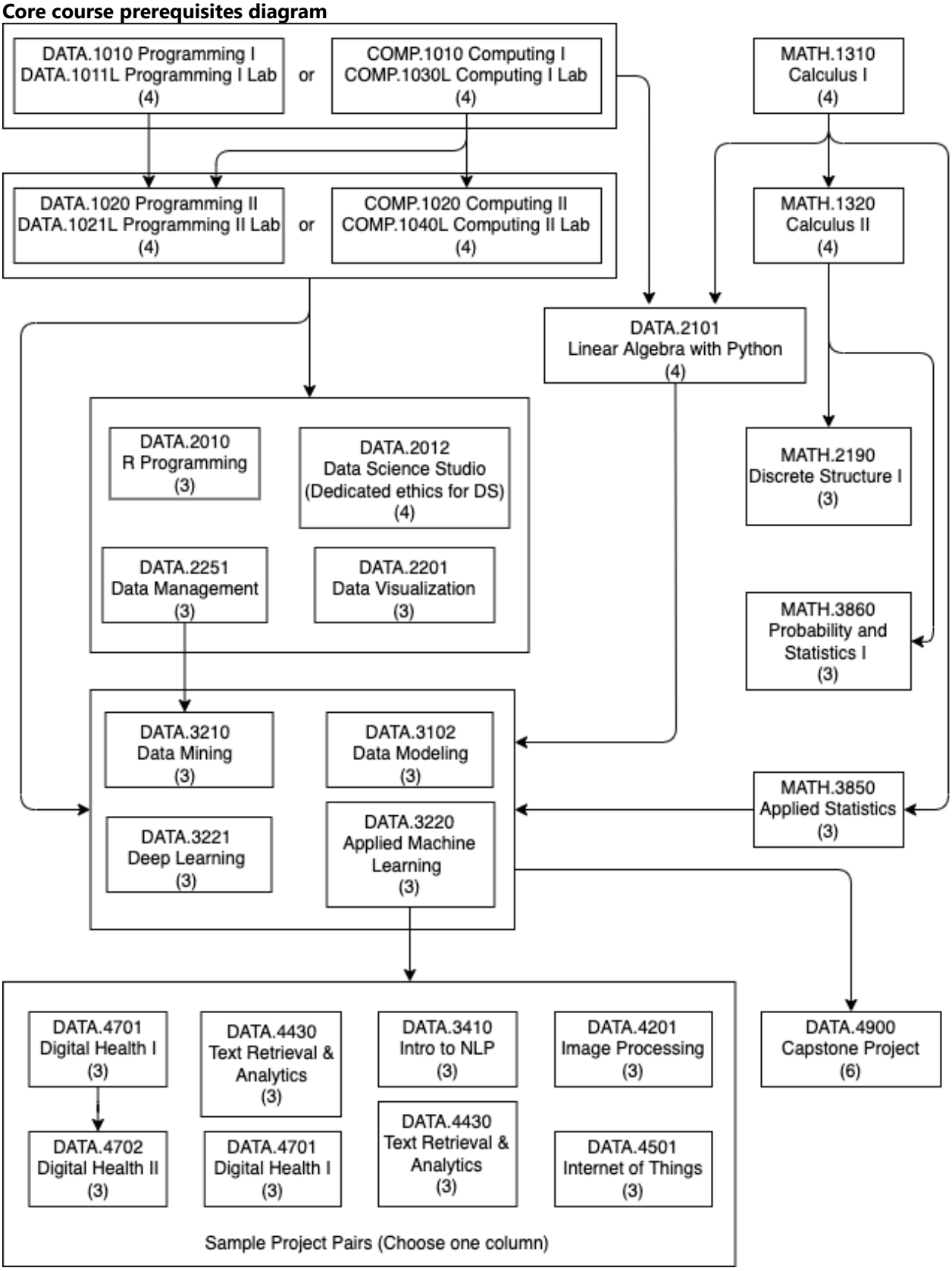
Form A: Curriculum Outline

All courses beginning with DATA are new courses. The rest are existing courses.

Required (Core) Courses in the Major (Total # courses required** = 22**)		
Course Number	Course Title	Credit Hours
DATA.1010 or COMP.1010	Programming I or Computing I	3
DATA.1011L or COMP.1030L	Programming I Lab or Computing I Lab	1
DATA.1020 or COMP.1020	Programming II or Computing II	3
DATA.1021L or COMP.1040L	Programming II or Computing II Lab	1
DATA.2010	R Programming	3
DATA.2012	Data Science Studio	4
DATA.2101	Linear Algebra with Python	4
DATA.2201	Data Visualization	3
DATA.2251	Data Management	3
DATA.3102	Data Modeling	3
DATA.3210	Data Mining	3
DATA.3220	Applied Machine Learning	3
DATA.3221	Deep Learning	3
MATH.1310	Calculus I	4
MATH.1320	Calculus II	4
MATH.2190	Discrete Structure I	3
MATH.3850	Applied Statistics	3
MATH.3860	Probability and Statistics I	3
See Appendix I	Project Pair 1	3
	Project Pair 2	3
See Appendix II	Capstone Project	6

	Sub Total Required Credits	66
Elective Courses (Total # courses required = 6***)*** *(attach list of choices if needed)*		
See Appendix III	Technical Elective 1	3
	Technical Elective 2	3
	Technical Elective 3	3
	Free Elective 1	3
	Free Elective 2	3
	Free Elective 3	3
	Sub Total Elective Credits	18
Distribution of General Education Requirements Attach List of General Education Offerings (Course Numbers, Titles, and Credits)		# of Gen Ed Credits
ENGL.1010 College Writing I		3
ENGL.1020 College Writing II		3
Arts and Humanities, including Literature and Foreign Languages (3 courses) (see Appendix IV)		9
Social Sciences (3 courses) (see Appendix IV)		9
Natural Sciences (3 Lecture + 3 Lab courses) (see Appendix V)		12
	Sub Total General Education Credits	36
Curriculum Summary		
	Total number of courses required for the degree	42
	Total credit hours required for degree	120
Prerequisite, Concentration or Other Requirements:		

Core course prerequisites diagram



Appendix I. Project Pair

A project pair consists of two courses, which must be all selected from one of the following three groups to deepen student's knowledge in a chosen area:

Course No.	Course Title	Credits
Group I		
DATA.3410	Introduction to Natural Language Processing	3
DATA.4430	Text Mining and Analytics	3
DATA.4701	Digital Health I	3
DATA.4702	Digital Health II	3
Group II		
DATA.4201	Image Processing	3
DATA.4501	Internet of Things	3
Group III		
COMP.4270	Computer Graphics I	3
COMP.4280	Computer Graphics II	3
COMP.4230	Computer Vision I	3

Appendix II. Capstone Project

In addition to the project pair of courses selected in a subarea that allows students to obtain a deeper knowledge in the chosen area, the capstone project provides an opportunity for students to apply the data science knowledge and skills they learn to solve real-life data-centric problems in domain application areas, either on research and development issues in different academic disciplines on campus or in industry. The capstone projects are directed jointly by the data science and computer science faculty and faculty in other departments across the campus or qualified technical staff mentors in companies or organizations off campus.

Appendix III. Technical and Free Electives

Technical electives

Any course at the 3000 level or higher required for the major at UMass Lowell in Data Science, Computer Science, Statistics, Mathematics, and Engineering that have not been used by the student to fulfill the requirement of the required courses can be used as a technical elective.

Any other courses offered by UMass Lowell that have not been used by the student to fulfill the requirements of the required courses and technical electives can be used as free electives.

Free electives

- These are almost any course offered by the university.
- Courses taken to fulfill this requirement must not be below the level of any required course.

The three technical elective and three free elective courses allow students to pursue other interests of their own choice. Students are encouraged to explore other domain application areas. For example, students may choose, among other disciplines, the following courses in economics and environment science that deal with massive data.

Course No.	Course Title	Credits
Economics		
ECON.2110	Statistics for Business and Economics I	3
ECON.2120	Statistics for Business and Economics II	3
ECON.4070	Econometrics	3
Environmental Science		
ENVI.3010	Geographic Information Systems in Earth & Environmental Science	3
ATMO.4130	Regional Weather and Climate Modeling	3
ATMO.4200	Introduction to Operational Numerical Weather Prediction	3
ATMO.4970	Research: Atmospheric Science	3
ENVI.4970	Research: Environmental Studies	3

- Prerequisites for the three courses in Economics:
    - ECON.2110: MATH.3850 Applied Statistics (required as a core course in BS in Data Science)
    - ECON.2120: ECON.2110
    - ECON.4070: ECON.2120
- Prerequisites for the four courses in Environmental Science:
    - ENVI.3010: None
    - ATMO.4130 and ATMO.4200: ENVI.2020 Earth Systems: Atmosphere and Oceans (3 credits) and ENVI.2040L Earth Systems: Atmosphere & Oceans Lab (1 credit). These two courses are to be taken together, which can be taken for credits for the general education on natural sciences. To go into this domain, students would need to choose ENVI.2020 and ENVI.2040L to fulfill part of their science requirements.

Providing this freedom for students to choose an application domain in our curriculum is particularly important for data science students. Likewise, students may also use these course slots to pursue a minor in other disciplines, such as a minor in computer science, a minor in math, and a minor in statistics, to name just a few.

Appendix IV. General Education

The Core Curriculum at UMass Lowell ensures that students are learning deeply and broadly, developing essential intellectual abilities that prepare our students to thrive in and contribute to their communities. The UMass Lowell Core addresses this challenge with a two-part framework of requirements: Breadth of Knowledge and Essential Learning Outcomes. Each student is required to take three courses (9 credit hours) from Arts and Humanities (AH) and three courses (9 credits) from Social Sciences (SS). Any course offered by AH departments can be used to fulfill the AH requirement and any course offered by SS departments can be used to fulfill the SS requirement.

UMass Lowell offers AH and SS courses in the following disciplines: Art and Design, Criminology and Justice Studies, Economics, English, History, Music, Philosophy, Political Science, Psychology, Sociology, and World Languages and Cultures.

Appendix V. Natural Sciences

The requirement of natural science electives for the BS in Data Science degree program is the same as that for the BS in Computer Science degree program. These are courses offered by one of the four natural science departments in the Kennedy College of Sciences:

- Biological Sciences
- Chemistry
- Environmental, Earth, and Atmospheric Sciences
- Physics and Applied Physics

Courses that fulfill this requirement must be classified as required or elective courses for the majors in those departments (with some exceptions). The Data Science faculty recommends that students take three 4-credit courses that include labs.

Reasonings

The proposed BS Data Science program trains undergraduate students to become qualified professionals for the data-driven industry. In particular, it provides a rigorous and systematic curriculum so that students, upon graduation, are armed with a solid theoretical foundation, and skilled with the state-of-the-art computing technologies, for processing and analyzing different types of data, including but not limited to, (1) relational data, (2) text data, and (3) image data. Relational data are in the form of numerical values or ordinal values, which include functional data governed by functions of one or more variables. The program is centered around the following learning objectives:

1) To be fluent in writing application programs and using various tools to wrangle, process, analyze, manage, and visualize data of different types.

2) To build a solid theoretical foundation of data-science methodologies, including data modeling, statistics, and machine learning.

3) To understand and be able to apply data ethics and regulations for developing data-driven applications.

4) To be able to apply data science knowledge and skills to solve real-life problems in domain applications through capstone projects.

5) To be effective in oral and written communications with peers, domain application personnel, administrators, and users.

6) The proposed curriculum consists of 120 credit hours, incorporating the existing computer science, statistics, and mathematics courses at UMass Lowell.

The program enrolls new students, helps retain current computer science majors in the department who have discovered that system-level development and management isn't their passion, and welcomes transfer students, including those with associate degrees in Computer Science, Information Technology, Mathematics, and Statistics.

The method of content delivery of the curriculum is the traditional classroom teaching in the setting of day school. The Miner School of Computer and Information Sciences will work closely with the Office of Career Services to develop co-op opportunities for data sciences majors. It will also work closely with the Dean's office of the Kennedy College of Sciences at UMass Lowell to develop "undergraduate design project" opportunities for its students, in collaboration with industry partners.

Overview

The Data Science curriculum consists of the following courses of 120 credits:

- 54 credits of required core courses in data science, math, and statistics.
- 6 credits of Project Pair courses.
- 6 credits of College Writing courses.
- 18 credits of General Education courses, where 9 credits are in Arts and Humanities (AH) and 9 credits are in Social Sciences (SS). These courses must also fulfill the requirements of ethics, oral & written communications, and diversity, as required for the CS major.
- 12 credits of natural science courses, as required for the CS major.
- 9 credits of Technical Elective courses, as required for the CS major.
- 9 credits of Free Elective courses.
- 6 credits of a Capstone Project.

Specifically,

1) **First-year** Data Science majors receive trainings to lay down a solid foundation of computer programming and data structures, calculus, and writing.

   Programming courses are divided into two tracks: the DS track and the CS track. The DS track starts with two courses on Python programming, one in each of the first two semesters. The CS track starts with the same existing two courses on C programming as Computer Science majors, one in each of the first two semesters. The DS track are directed toward application-level programming, while the CS track are directed toward system-level programming.

   Depending on students' backgrounds and interests, they may choose the DS track or the CS track in the first semester, and switch from the CS track to the DS track in the second semester. For example, suppose that John starts the first programming course in the CS track as a CS major, but later realizes that he is more interested in application-level programming and would like to gain experience on using the rich Python libraries available for data science, then he may switch major to DS and take the second programming course in the DS track in the second semester. Likewise, if Mary likes to pursue a CS career, but lacks exposure to programming in high school, then she may choose to take the first programming course in the DS track to obtain programming experience using Python at the application level before proceeding to the first programming course for the CS major that is system oriented using the C language.

   Fall
   1. (**DS Track**) DATA.1010 Programming I and DATA.1011 Programming I Lab, or (**CS Track**) COMP.1010 Computing I and COMP.1010L Computing I Lab
   2. MATH.1310 Calculus I
   3. ENGL.1010 College Writing I
   4. Science 1 (Lecture and Lab)

   Spring
   1. (**DS Track**) DATA.1020 Programming II and DATA.1021 Programming II Lab, or (**CS Track**) COMP.1020 Computing II and COMP.1040L Computing II Lab
   5. MATH.1320 Calculus II
   6. ENGL.1020 College Writing II
   7. Science 2 (Lecture & Lab)

2) **Second-year** DS majors start to explore data science. The purpose is for students to be fluent in writing programs using languages commonly used in data science, math, and statistics.

   Transfer students may start taking any of the DATA.2xxx or DATA.3xxx courses depending on the courses they have taken in prior institutions. In general, transfer students are expected to take DATA.2012 Data Science Studio with an emphasis on ethics for Data Science as an entry point to the DS program.

   Fall
   1. DATA.2010 R Programming
   2. DATA.2251 Data Management

3. MATH.2190 Discrete Structure I
4. Science 3 (Lecture & Lab)
5. Gen Ed 1

Spring

1. DATA.2101 Linear Algebra with Python
2. DATA.2051 Data Visualization
3. MATH.3850 Applied Statistics
4. Gen Ed 2
5. Free Elective 1

3) **Third-year** DS majors advance their data science foundation and skills. Students will also encourage to select courses from other disciplines that are more data driven as some of their technical and free electives. An initial set of domain-application courses is provided identified for DS students to consider; more will be added to the list when additional data-driven courses in other disciplines are offered.

Fall

1. DATA.2012 Data Science Studio
2. DATA.3210 Data Mining
3. MATH.3860 Probability and Statistics I
4. Gen Ed 3
5. Technical Elective 1

Spring

1. DATA.3102 Data Modeling
2. DATA.3220 Applied Machine Learning
3. Gen Ed 4
4. Technical Elective 2
5. Free Elective 2

4) **Fourth-year** DS majors pursue a particular direction of data science in one of the three groups for the project pair and complete a capstone project.

Fall

1. DATA.3221 Deep Learning
2. Project Pair 1
3. Gen Ed 5
4. Technical Elective 3
5. Free Elective 3

Spring

1. DATA.4900 Capstone Project
2. Project Pair 2
3. Gen Ed 6

A Sample Course Grid

Semester	Courses	Credits	Total Credits
1	**DS Track 1** DATA.1010 Programming I DATA.1011 Programming I Lab OR **CS Track 2** COMP.1010 Computing I COMP.1010L Computing I Lab MATH.1310 Calculus I ENGL.1010 College Writing I Science 1 (Lecture & Lab)	 3 1 4 3 4	15
2	**DS Track 1** DATA.1020 Programming II DATA.1021 Programming II Lab OR **CS Track 2** COMP.1020 Computing II COMP.1020L Computing II Lab MATH.1320 Calculus II ENGL.1020 College Writing II Science 2 (Lecture & Lab)	 3 1 4 3 4	15
3	DATA.2010 R Programming DATA.2251 Data Management MATH.2190 Discrete Structure I Science 3 (Lecture & Lab) Gen Ed 1	3 3 3 4 3	16
4	DATA.2101 Linear Algebra with Python DATA.2051 Data Visualization MATH.3850 Applied Statistics Gen Ed 2 Free Elective 1	4 3 3 3 3	16
5	DATA.2012 Data Science Studio DATA.3210 Data Mining MATH.3860 Probability and Statistics I Gen Ed 3 Technical Elective 1	4 3 3 3 3	16

6	DATA.3102 Data Modeling DATA.3220 Applied Machine Learning Gen Ed 4 Technical Elective 2 Free Elective 2	3 3 3 3 3	15
7	DATA.3221 Deep Learning Project Pair I Gen Ed 5 Technical Elective 3 Free Elective 3	3 3 3 3 3	15
8	DATA.4900 Capstone Project Project Pair II Gen Ed 6	6 3 3	12
Total			**120**

Form B: LOI Goals and Objectives

Goal	Measurable Objective	Strategy for Achievement	Timetable
Maintain a satisfactory standing.	GPA 2.5 or above on 1st year classes	Take the required courses, work in labs, do homework assignments, participate in discussions and projects, and see faculty during office hours. Form study groups.	1st year
Become a data science programmer.	Be able to write application programs and use various tools to wrangle, process, analyze, and manage data of different types.	Same as above and carry out large-scale coding projects related to real-world problems	2nd year
Become a data analysis and modeler.	Be able to use advanced techniques and tools to analyze data science problems.	Same as above with a focus on analytic skills and data modeling	3rd year
Become a data scientist with solid domain knowledge in a chosen discipline and in-depth knowledge in a chosen subarea of data science.	Be able to work on a data-driven domain application in a discipline in science, healthcare, and economics.	Same as above, In particular, finish 3 domain application courses and 2 project-sequence course	4th year

Form C: LOI Program Enrollment

	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
New Full-Time	60	66	72	79	86
Continuing Full-Time	0	41	74	107	134
New Part-Time					
Continuing Part-Time					
Totals	**60**	**107**	**146**	**186**	**220**

Form D: LOI Program Budget

One Time/ Start Up Costs		***Annual Expenses***				
	Cost Categories	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
1M Star-ups	Full Time Faculty *(Salary & Fringe)*	95K	229K	362K	455K	630K
	Part Time/Adjunct Faculty *(Salary & Fringe)*	10K	20K	30K	40K	40K
	Staff	100K	100K	200K	200K	200K
	General Administrative Costs (break down by category-i.e. accreditation, credentialing, etc.)	10K	10K	10K	10K	10K
	Instructional Materials, Library Acquisitions	0	0	0	0	0
	Facilities/Space/Equipment	(1) Office for 1 new NTT. (2) Office space for system admin (3) Office space for TAs	(1) Office for 1 new TT and research lab. (2) Office space for TAs	(1) Offices for 2 new TT and research lab. (2) space for TAs	(1) Office for 1 new TT and research lab. (2) space for TAs	
	Field & Clinical Resources	0	0	0	0	0
	Marketing	10K	10K	0	0	0
	Other (Specify)	26K	52K	104K	156K	156K

	Teaching Assistants	(1 TA)	(2 TAs)	(4 TAs)	(6 TAs)	(6 TAs)
	TOTALS	251K	421K	706K	861K	1.036M

One Time/Start-Up Support		***Annual Income***				
	Revenue Sources	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
	Grants					
	Tuition (based on in-state tuition and mandatory fees: $15,850 + $720)	646K	1.346M	2.089M	2.919M	3.715M
	Fees (college specific fees $850 / year)	22K	59K	81K	103K	122K
	Departmental					
	Reallocated Funds					
	Other (specify)					
	TOTALS	679K	1.405M	2.170M	3.021M	3.837M