APPROVED BY SENATE
04/26/2021

EP.21.113_FINAL
Approved by EP 04/19/2021

: ASTRONOMY + DATA SCIENCE, BSLAS

In Workflow

1. U Program Review (dforgacs@illinois.edu; eastuby@illinois.edu; aledward@illinois.edu)
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18. Board of Trustees (none)
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Approval Path

1. Tue, 23 Mar 2021 20:25:42 GMT
   Deb Forgacs (dforgacs): Approved for U Program Review
2. Tue, 23 Mar 2021 20:33:10 GMT
   Leslie Looney (lwl): Approved for 1430 Head
3. Tue, 23 Mar 2021 20:46:33 GMT
   Bo Li (libo): Approved for 1583 Head
4. Tue, 23 Mar 2021 21:12:19 GMT
   Elsa Gunter (egunter): Approved for 1434 Head
5. Tue, 23 Mar 2021 21:13:49 GMT
   Emily Knox (knox): Approved for 1992 Head
6. Tue, 23 Mar 2021 21:17:24 GMT
   Jeremy Tyson (tyson): Approved for 1257 Head
7. Wed, 24 Mar 2021 16:27:35 GMT
   Brooke Newell (bsnewell): Approved for KP Committee Chair
8. Wed, 24 Mar 2021 16:49:38 GMT
   Kelly Ritter (ritterk): Rollback to KP Committee Chair for KV Dean
9. Tue, 30 Mar 2021 18:58:40 GMT
   Brooke Newell (bsnewell): Approved for KP Committee Chair
10. Tue, 30 Mar 2021 20:26:17 GMT
    Kelly Ritter (ritterk): Approved for KV Dean
11. Tue, 30 Mar 2021 20:42:32 GMT
    Candy Deaville (candyd): Approved for KP Dean
12. Tue, 30 Mar 2021 21:38:51 GMT
    Emily Knox (knox): Approved for LP Dean
13. Tue, 30 Mar 2021 21:57:55 GMT
    Amy Elli (amyelli): Approved for KV Dean
14. Tue, 30 Mar 2021 21:58:33 GMT
    Amy Elli (amyelli): Approved for KV Dean
15. Tue, 30 Mar 2021 22:07:35 GMT

John Wilkin (jpwilkin): Approved for University Librarian

16. Mon, 05 Apr 2021 13:20:02 GMT
    Kathy Martensen (kmartens): Approved for Provost

New Proposal

Date Submitted:Mon, 22 Mar 2021 20:35:46 GMT

Viewing:: Astronomy + Data Science, BSLAS

Changes proposed by: Amy Elli

Proposal Type

Proposal Type:

Major (ex. Special Education)

Proposal Title:

If this proposal is one piece of a multi-element change please include the other impacted programs here.*example: A BS revision with multiple concentration revisions*

Establish the BSLAS in Astronomy + Data Science in the Department of Astronomy within the College of Liberal Arts & Sciences

EP Control Number

EP.21.113

Official Program Name

Astronomy + Data Science, BSLAS

Effective Catalog Term

Fall 2022

Sponsor College

Liberal Arts & Sciences

Sponsor Department

Astronomy

Sponsor Name

Leslie Looney, Chair

Sponsor Email

lwl@illinois.edu

College Contact

Kelly Ritter

College Contact Email

ritterk@illinois.edu

Program Description and Justification

Provide a*brief*description and justification of the program, including highlights of the program objectives, and the careers, occupations, or further educational opportunities for which the program will prepare graduates, when appropriate.

The Astronomy + DS degree plan incorporates simultaneously a strong foundation in data science and Astronomy, including a research or discovery experience as part of the degree.
The degree has three different components:
1. The data science core coursework (28-31 hours)
a. This coursework is comprised of:
i. Two (2) courses from Statistics
ii. Two (2) courses from Computer Science
iii. Two (2) courses from the iSchool
iv. Two (2) courses from Mathematics:
2. Astronomy coursework in the area of specialization (31-32 hours)
3. A research experience in any combination of ASTR 390 (Individual Study) or ASTR 490 (Senior Thesis) (3 hours), wherein the student integrates data science and astronomy.
See Appendix A for further course details.
Ubiquitous digital technology and the generation of massive amounts of data are rapidly transforming society and multiple fields of inquiry. This transformation has created exciting opportunities and worrisome scenarios across multiple domains of human endeavor. Like the industrial technologies of the early-20th century, the new digital technologies of the early-21st century have great potential to transform society, for good or ill. The University of Illinois has a high calling to prepare students to lead society's digital transformation.
There is substantial demand, both from students and from employers, for educational programs in data science. A 2017 study by researchers at IBM and Burning Glass Technologies predicts the demand for Data Scientists will grow by 28% by 2020. (Markow, Braganza, Taska, Miller, and Hughes, "The Quant Crunch: How the demand for data science skills is disrupting the job market", published by IBM, Burning Technologies, and the Business-Higher Education Forum, 2017. Available at https://www.ibm.com/downloads/cas/3RL3VXGA.) Enrollment in the undergraduate majors "Statistics" and "Statistics and Computer Science," which provide students access to some of the competencies of data science, have grown by a factor of six in the last ten years.
Data science is emerging as a subject of great importance in many domains of human and scholastic endeavor. National policy documents for data science majors emphasize that engagement with an application domain is an important part of data science education. The University of Illinois' white paper on data science education recommended the development of "Astronomy & Data Science Majors" as an approach to offering broad collaborative opportunities for Illinois students to engage with data science.
Astronomy as a field is going through such a transformation. Astronomers are about to be awash in data in a way that has been unheard of to date with the Legacy Survey of Space and Time (LSST) at the Vera C. Rubin Observatory, to which Illinois is an important contributor. LSST will revolutionize astronomy by opening the time domain, scanning the entire southern night sky once every three to four nights. This will yield deep, high-resolution, multi-color digital movies of the transient sky over timescales from seconds to years. The scientific payoff will occupy center stage in the coming decade. LSST will study the demographics of the changing night-sky, discovering unprecedented numbers of asteroids, periodic variables, extragalactic quasars powered by supermassive black holes, as well as transient sources such as flare stars, microlensing events, cataclysmic variables, supernovae, and extremely rare sources such as tidal disruption events and kilonovae.
Astronomers are preparing for the tsunami of LSST data every night. We expect that there will be significant brightness changes to nearly 10 million objects every single night for over a decade! It is impossible to keep track and sift through the transient sources without advanced computational techniques utilizing artificial intelligence. Modern astronomers need data science training as LSST is only one of the first types of these large surveys, but there are many others being planned.

Corresponding Degree

BSLAS Bachelor of Science in Liberal Arts and Sciences

Is this program interdisciplinary?

Yes

Interdisciplinary Colleges and Departments (list other colleges/departments which are involved other than the sponsor chose above)

In Spring 2017, the College of Liberal Arts & Sciences submitted an Investment for Growth Proposal to “Jump Start Data Science”, focusing on undergraduate data science education. Interim Provost John Wilkin supported the proposal, but called on LAS to work with three colleges (Engineering, the iSchool, and the Gies College of Business) to develop a collaborative approach to undergraduate data science at Illinois.

Those deans formed a task force (herein the “Data Science Education Task Force” or DSETF) to explore opportunities and make proposals for undergraduate data science education at Illinois. The DSETF conducted its work during academic years 2017—2018 and 2018—2019. At the core of their work was the vision that every Illinois undergraduate should have the opportunity to have a meaningful exposure to data science.

In February 2019, the four deans agreed to support a shared framework for X+Data Science majors, based on suggestions from the DSETF. The framework consisted of the following pieces.
1) A set of core competencies and common features which will be expected of X+Data science majors, together with a reference standard set of courses and activities that fulfills the data science portion of those expectations.
2) Each college can propose its own X+Data Science majors, which will be majors of that college. They may differ from the reference standard approach. When they do so, they should explain how the proposed major provides the expected competencies and features of an X+Data Science major in a manner that is appropriate for their students.
3) The deans will engage with the campus leadership to establish a Data Science Education committee. The committee will:
• Keep track of offerings related to data science to facilitate collaboration and reduce redundancy
• Facilitate the development of data science programs by connecting undergraduate data science education resources across the university
• Advise colleges on matters related to undergraduate data science education
• Review X+Data Science major proposals, commenting on how they meet the expectations for X+Data Science majors and engage collaboratively and strategically with the university’s resources in data science education

College

Liberal Arts & Sciences

Department

Statistics

Do you need to add an additional interdisciplinary relationship?

Yes

College

Grainger College of Engineering

Department

Computer Science

Do you need to add an additional interdisciplinary relationship?

Yes

College

Information Science, School of

Department

Information Sciences

Do you need to add an additional interdisciplinary relationship?

Yes

College

Liberal Arts & Sciences

Department

Mathematics

Academic Level

Undergraduate

Will you admit to the concentration directly?

No

Is a concentration required for graduation?

No

CIP Code

40.0201 - 40.0201

Is This a Teacher Certification Program?

No

Will specialized accreditation be sought for this program?

No

Institutional Context

University of Illinois at Urbana-Champaign

Describe the historical and university context of the program's development. Include a short summary of any existing program(s) upon which this program will be built.

Explain the nature and degree of overlap with existing programs and, if such overlap exists, document consultation with the impacted program's home department(s).

The university's 2018 Strategic Plan The Next 150 calls for "[p]rovid[ing] all Illinois students the opportunity to have a meaningful exposure to data science."

In Spring 2017, the College of Liberal Arts & Sciences submitted an Investment for Growth Proposal to "Jump Start Data Science," focusing on undergraduate data science education. Interim Provost John Wilkin supported the proposal, but called on LAS to work with the colleges (Engineering, the iSchool, and the Gies College of Business) to develop a collaborative approach to undergraduate data science at Illinois. Those deans formed a task force (herein the "Data Science Education Task Force" or DSETF) to explore opportunities and make proposals for undergraduate data science education at Illinois. The DSETF conducted its work during academic years 2017—2018 and 2018—2019. At the core of their work was the vision that every Illinois undergraduate should have the opportunity to have a meaningful exposure to data science. The degree program differs from other undergraduate degree programs in data science because it provides the student with substantial exposure to data science.

Data science is an area of scholarship involving principles for data collection, storage, integration, analysis, inference, communication, and ethics in the context of the ubiquitous collection of massive data sets that have emerged in recent years. The field draws from a number of existing fields, including information technology, computer science, statistics, mathematics, and business analytics. However, core data science concepts are not being conveyed by mainstream training in any single other field because data science is not reducible to any of the preexisting fields. (This paragraph adapted from p. 7 of Data Science for Undergraduates: Opportunities and Options. Washington, DC: The National Academies Press. https://doi.org/10.17226/25104) Data science is an emerging and important technique in astronomy, but not in traditional astronomy or many branches of modern theoretical astrophysics.

One of the hallmarks of data science is that it outward-looking, engaging richly with multiple domains of application, including astronomy. In response to the university's strategic plan and in recognition of the interdisciplinary and outward-looking nature of data science, the Departments of Computer Science, Mathematics, Statistics, the Gies College of Business, and the I-School collaborated to develop a framework for Astronomy & Data Science majors, enabling students to learn the principles of data science while engaging deeply with Astronomy.

In the Astronomy & Data Science program, the Astronomy Department offers coursework and advising in Astronomy; Computer Science, Mathematics, Statistics, and the i-School offer a core framework of courses and advising in data science; and the Astronomy program provides coursework and independent work/research experiences that integrate Astronomy and data science. We have a unique opportunity to meld astronomy research with Data Science due to the boom in Astronomy large surveys.

The degree program differs from other undergraduate degree programs in data science because it provides the student with substantial exposure to data science and to Scholarship in Astronomy, especially cutting-edge large surveys. It differs from the CS & Astronomy degree because the focus beyond Astronomy is in data science, which overlaps with but is distinct from computer science.

University of Illinois

Briefly describe how this program will support the University's mission, focus and/or current priorities. Demonstrate the program's consistency with and centrality to that mission.

The university continually examines its educational programs to respond to emerging student demand, societal need, and economic opportunity. Data science has rapidly emerged as a field for which there is broad-based demand across many areas of economic activity and across many fields of scholarship. For example, astronomy is preparing for a tsunami of data with the new and upcoming surveys. We need students trained in how to use these data in Astronomy to best leverage our participation. The university recognized the general need in its 2018 Strategic Plan The Next 150, which called on the to "[p]rovide all Illinois students the opportunity to have a meaningful exposure to data science." The degree program proposed here is part of that response.

State of Illinois

Indicate which of the following goals of the Illinois Board of Higher Education's Strategic Initiative are supported by this program: (choose all that apply)

Educational Attainment - increase educational attainment to match the best-performing states.
High Quality Credentials to Meet Economic Demand - Increase the number of high-quality post-secondary credentials to meet the demands of the economy and an increasingly global society.
Integration of Educational, Research and Innovation Assets - Better integrate Illinois' educational, research and innovation assets to meet economic needs of the state and its regions.

Describe how the proposed program supports these goals.

We have a unique opportunity to meld astronomy research with Data Science due to the boom in Astronomy large surveys, providing students direct access to large datasets that vary with time. With Illinois and the US heavily engaged in these large astronomical surveys, this training will easily address the above goals. The data science taught in the courses, integrated with modern astronomy research, will provide essential training for our students. This type of training will increase educational attainment for our students and prepare them for high demand positions (already many of our graduates are accepting jobs in data science and this major will increase this trend). Astronomy driven surveys and astronomy trained students are already bringing jobs to Illinois, and we hope that with this new major the future will be as bright as the stars.

Admission Requirements

Desired Effective Admissions Term

Fall 2022

Provide a brief narrative description of the admission requirements for this program. Where relevant, include information about licensure requirements, student background checks, GRE and TOEFL scores, and admission requirements for transfer students.

Same requirements for the existing CS + Astronomy degree, which means the requirements are handled at the campus level.

Describe how critical academic functions such as admissions and student advising are managed.

Admissions is managed through campus. The Departments of Statistics and Computer Science and the i-School will provide advising for the data science portion of the degree program. Astronomy advising will be done by the Astronomy advisor.

Enrollment

Number of Students in Program (estimate)

Year One Estimate

5

5th Year Estimate (or when fully implemented)

20

Estimated Annual Number of Degrees Awarded

Year One Estimate

0

5th Year Estimate (or when fully implemented)

5

What is the matriculation term for this program?

Fall

What is the typical time to completion of this program?

4 years

What are the minimum Total Credit Hours required for this program?

62

Delivery Method

This program is available:

On Campus

Budget

Will the program or revision require staffing (faculty, advisors, etc.) beyond what is currently available?

No

Resource Implications

Facilities

Will the program require new or additional facilities or significant improvements to already existing facilities?

No

Technology

Will the program need additional technology beyond what is currently available for the unit?

No

Non-Technical Resources

Will the program require additional supplies, services or equipment (non-technical)?

No

Resources

For each of these items, be sure to include in the response if the proposed new program or change will result in replacement of another program(s). If so, which program(s), what is the anticipated impact on faculty, students, and instructional resources? Please attach any letters of support/ acknowledgement from faculty, students, and/or other impacted units as appropriate.

Attach File(s)

CS Support for Four X+DataScienceProposals 2021-03-04.pdf
STAT Support 4X DS Letter.pdf
Math Support for Four X DataScienceProposals2021-03-08.pdf
iSchool X DS Support Letter.pdf

Faculty Resources

Please address the impact on faculty resources including any changes in numbers of faculty, class size, teaching loads, student-faculty ratios, etc. Describe how the unit will support student advising, including job placement and/or admission to advanced studies.

We suspect an increase in the core Astronomy courses, but we have the capacity for this. The Departments of Statistics and Computer Science and the i-School will provide advising for the data science portion of the degree program. Astronomy advising will be done by the Astronomy advisor.

Library Resources

Describe your proposal's impact on the University Library's resources, collections, and services. If necessary please consult with the appropriate disciplinary specialist within the University Library.

Current collections and services are adequate for the proposed program as existing courses from Astronomy, Mathematics, Statistics, Computer Science, and School of Information Sciences are being used in the curricula.

Instructional Resources

Will there be any reduction in other course offerings, programs or concentrations by your department as a result of this new program/proposed change?

No

Does the program include other courses/subjects impacted by the creation/revision of this program?

Yes

Required courses

MATH 220 - Calculus
MATH 221 - Calculus I
MATH 227 - Linear Algebra for Data Sci
MATH 257 - Linear Algebra w Computat Appl
STAT 107 - Data Science Discovery
STAT 207 - Data Science Exploration
CS 277 - Algo & Data Stru for Data Sci
CS 307 - Model & Learning in Data Sci
IS 467 - Ethics & Policy for Data Scien

IS 477 - Data Mgmt, Curation, & Reprodu

Explain how the inclusion or removal of the courses/subjects listed above impacts the offering departments.

The reference data science core includes the following courses:

Math 220 or 221* and 227 or 257; Stat 107 and 207; CS 277 and 307; IS 467 and 477

The explanation for these courses and the context for the interdisciplinary data science major is attached.

*We have excluded MATH 234 from the reference data science core due to requiring MATH 231 and MATH 241

Financial Resources

How does the unit intend to financially support this proposal?

None

Will the unit need to seek campus or other external resources?

No

Are you seeking a change in the tuition rate or differential for this program?

Yes

If yes, please enter your college budget office contact information and have them contact provostbudget@illinois.edu for next steps.

Bob Kessler, rkessler@illinois.edu
Mike Wellens, wellens@illinois.edu

Market Demand

What market indicators are driving this proposal? If similar programs exist in the state, describe how this program offers a unique opportunity for students:

The ubiquity of massive data sets in Astronomy and in other fields of the sciences and humanities has created enormous demand for data scientists across many domains of economic activity. Astronomy has seen an increase in enrollment of three-fold in the last ten years. Enrollment in the Statistics major has increased seven-fold in the last ten years, and other majors that involve data science have seen similar explosion in interest. But there is tremendous demand not only for coding-intensive data scientists but also for data scientists who can work collaboratively in application domains. Astronomy, with our “safe” and very large, yet open, datasets, are perfect for student learning and preparation for future data science positions.

What type of employment outlook should these graduates expect? Explain how the program will meet the needs of regional and state employers, including any state agencies, industries, research centers, or other educational institutions that expressly encourage the program's development.

The ubiquity of large data arising from an increasingly connected world means that data scientists and those who understand the human and policy implications of data are in demand in all domains of economic activity. Astronomy majors are already in demand for these types of positions. We need to take advantage of this and do our best to prepare our majors for the types of jobs that deal with large data and with statistical analysis of data, including machine learning.

What resources will be provided to assist students with job placement?

The Astronomy advisor, the Careers in Astronomy course, and faculty will discuss career opportunities with Astronomy undergraduates at various times throughout their time in the Department. These will include counseling and examples of career paths in academia, research, and industry with a data science emphasis. We will also bring in guest speakers to the Careers in Astronomy course to provide concrete examples of careers leveraged off astronomy degrees.

Program Regulation and Assessment

Briefly describe the plan to assess and improve student learning, including the program's learning objectives; when, how, and where these learning objectives will be assessed; what metrics will be used to signify student's achievement of the stated learning objectives; and the process to ensure assessment results are used to improve student learning. (Describe how the program is aligned with or meets licensure, certification, and/or entitlement requirements, if applicable).

The current plan is for the Astronomy advisor to assess the learning objectives for our Astronomy & Data Science majors. Success in the advanced astronomy courses requires success in prerequisites, such as Physics courses. We carefully monitor student progress through the first two years of the major in the advising process, giving mentoring where necessary. During the third year, we evaluate the student's progress of in the ASTR 310 course through student assessments and projects to evaluate the impact of astronomy and data science. Finally, the research experience is assessed by the Director of Undergraduate Studies via the final project, required for the major. These project final reports will provide an evaluation of the integration of data science and astronomy, allowing for systematic audits of the program overall.

Is the career/profession for graduates of this program regulated by the State of Illinois?

No

Program of Study

"Baccalaureate degree requires at least 120 semester credit hours or 180 quarter credit hours and at least 40 semester credit hours (60 quarter credit hours) in upper division courses" (source: https://www.ibhe.org/assets/files/PrivateAdminRules2017.pdf). For proposals for new bachelor's degrees, if this minimum is not explicitly met by specifically-required 300- and/or 400-level courses, please provide information on how the upper-division hours requirement will be satisfied.

All proposals must attach the new or revised version of the Academic Catalog program of study entry. Contact your college office if you have questions.

For new programs, attach Program of Study

Astronomy Data Science ACADEMIC CATALOG ENTRY 3-25-21).docx
BSLAS in Astronomy +DS proposal REV 3-25-21.doc

Catalog Page Text

Catalog Page Text: Description of program for the catalog page. This is not official content, it is used to help build the catalog pages for the program. Can be edited in the catalog by the college or department.

E-mail: data-science@illinois.edu
Minimum required major and supporting course work normally equates to 62-66 hours
General education: Students must complete the Campus General Education requirements including the campus general education language requirement.
Twelve hours of 300 and 400-level courses must be taken on this campus.
Minimum hours required for graduation: 120 hours

Departmental distinction: To graduate with distinction requires a specified minimum grade point average in all Computer Science, Statistics, Information Science, and Mathematics courses listed below. A GPA of 3.25 is required for Distinction, 3.5 for High Distinction, and 3.75 for Highest Distinction.

Statement for Programs of Study Catalog

Code	Title	Hours
Required Data Science Core		**28-31**
Mathematical Foundations (6-9 hours)		
Calculus:Select one of the following:		
MATH 220	Calculus	4-5
or MATH 221	Calculus I	
Linear Algebra: Select one of the following:		
MATH 227	Linear Algebra for Data Science	3
MATH 257	Linear Algebra with Computational Applications	3
MATH 225	Introductory Matrix Theory	2
MATH 415	Applied Linear Algebra	3 or 4
(MATH 227or 257 is recommended)		
Data Science Fundamentals (12 hours)		
STAT 107	Data Science Discovery	4
(crosslisted withCS 107andIS 107)		
STAT 207	Data Science Exploration	4
CS 307	Modeling and Learning in Data Science	4
Computational Fundamentals (4 hours)		
CS 277	Algorithms and Data Structures for Data Science	4
Ethics and Responsibility in Data Science (6 hours)		
IS 467	Ethics and Policy for Data Science	3
IS 477	Data Management, Curation & Reproducibility	3
Required Astronomy Coursework		**31-32**
PHYS 211	University Physics: Mechanics	4
PHYS 212	University Physics: Elec & Mag	4
PHYS 213	Univ Physics: Thermal Physics	2
PHYS 214	Univ Physics: Quantum Physics	2
MATH 231	Calculus II	3
MATH 241	Calculus III	4
ASTR 210	Introduction to Astrophysics	3
ASTR 310	Computing in Astronomy	3
Advanced Astronomy Courses - Select two courses from the following:		6-7
ASTR 404	Stellar Astrophysics	
ASTR 405	Planetary Systems	
ASTR 406	Galaxies and the Universe	
ASTR 414	Astronomical Techniques	
Research or Discovery Experience		**3**
ASTR 390	Individual Study	
or ASTR 490	Senior Thesis	
One of the most important skills a student will gain in an Astronomy & Data Science degree will be the ability to present astronomical data in meaningful ways. A research or discovery experience is as much as pillar of this degree program as both the data science core coursework (Part 1) and the coursework in Astronomy (Part 2).		
This experience should be developed with an advisor before the end of a student's sophomore year and result in the creation of one or more artifacts documenting the experience. A minimum of 3 credit hours must be specifically designated to the preparation and the completion of the experience component.		

Examples of possible experiences may include:	
# A semester study-abroad with at one or more courses focused on discovery while attending the international institution.	
# A multi-semester capstone experience within the student's area of specialization.	
# A semester co-op experience outside Champaign-Urbana focused on a subject within the student's area of specialization.	
# A multi-semester undergraduate research experience under the direction of Illinois faculty.	
# A summer NSF REU program focused within a student's area of specialization.	
Total Hours	62-66

EP Documentation

DMI Documentation

Program Reviewer Comments

Kelly Ritter (ritterk) (Wed, 24 Mar 2021 16:49:38 GMT): Rollback: Rollback per KR and JM email 3/24/21

Key: 1021

Proposal for BSLAS in Astronomy + Data Science

Proposal Title: Establish the BSLAS in Astronomy + Data Science

Proposed effective date: Fall 2022

Sponsor(s): Professor Leslie Looney, Chair of the Department of Astronomy, lwl@illinois.edu, 217-244-3615

College contact: Kelly Ritter, Associate Dean for Curricula and Academic Policy, College of Liberal Arts. ritterk@illinois.edu, (217) 333-1350

PROGRAM DESCRIPTION and JUSTIFICATION

1) **Provide a brief description but concise description of your proposal.** *For example, if proposing revisions to a curriculum, state specifically what is changing. Where applicable, note whether stated program changes include additional requirements in the form of prerequisite courses. Requests for curriculum revisions must be accompanied by a table which clearly outlines the current requirements and the proposed revisions. This information may be submitted as an appendix. See Appendix A for an example. Please provide pertinent information only.*

The Astronomy+DS degree plan incorporates simultaneously a strong foundation in data science and Astronomy, including a research or discovery experience as part of the degree.

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1. The data science core coursework (28-31 hours)
    a. This coursework is comprised of:
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2. Astronomy coursework in the area of specialization (31-32 hours)
3. A research experience in any combination of ASTR 390 (Individual Study) or ASTR 490 (Senior Thesis) (3 hours), wherein the student integrates data science and astronomy.

See Appendix A for further course details.

2) **Provide a justification of the program**, *including how your unit decided to create this program, highlights of the program objectives, and the careers, occupations, or further educational opportunities for which the program will prepare graduates, when appropriate*.

Ubiquitous digital technology and the generation of massive amounts of data are rapidly transforming society and multiple fields of inquiry. This transformation has created exciting opportunities and worrisome scenarios across multiple domains of human endeavor. Like the industrial technologies of the early-20th century, the new digital technologies of the early-21st century have great potential to transform society, for good or ill. The University of Illinois has a high calling to prepare students to lead society's digital transformation.

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Astronomers are preparing for the tsunami of LSST data every night. We expect that there will be significant brightness changes to nearly 10 million objects every single night for over a decade! It is impossible to keep track and sift through the transient sources without advanced computational techniques utilizing artificial intelligence. Modern astronomers need data science training as LSST is only one of the first types of these large surveys, but there are many others being planned.

[1] Markow, Braganza, Taska, Miller, and Hughes, "The Quant Crunch: How the demand for data science skills is disrupting the job market", published by IBM, Burning Technologies, and the Business-Higher Education Forum, 2017. Available at https://www.ibm.com/downloads/cas/3RL3VXGA.

3) In addition, please provide an answer as to how your undergraduate degree (120 hours of coursework) will satisfy this requirement: IBHE requires that all degree programs contain at least 40 credit hours in upper division courses as part of their overall degree. Not all 40 hours need to be in your major. Simply state how many of those 40 hours are achieved in your major. Upper division courses have been described as 300- and 400- level coursework and some 200-level courses in which multiple prerequisites are required.

The major has 39-40 hours of upper division courses. This includes 15 hours of 200-level courses that have multiple prerequisites, such as the Physics sequence and Introduction to Astrophysics.

Is this program interdisciplinary? Yes / No The Astronomy + Data Science program is a degree involving the study of data science in the context of Astronomy. It is offered as a collaboration of the Department of Astronomy with the Departments of Computer Science, Mathematics, Statistics, and the School of Information Sciences.

INSTITUTIONAL CONTEXT (new majors and degrees ONLY)

University of Illinois at Urbana-Champaign
Mission: The University of Illinois at Urbana-Champaign is charged by our state to enhance the lives of the citizens in Illinois, across the nation and around the world through our leadership in learning, discovery, engagement and economic development.

1) Describe the historical and university context of the program's development. Include a short summary of any existing program(s) upon which this program will be built. Also, explain the nature and degree of overlap with existing programs and, if such overlap exists, document consultation with the impacted program's home department(s).

The university's 2018 Strategic Plan *The Next 150* calls for "[p]rovid[ing] all Illinois students the opportunity to have a meaningful exposure to data science."

Data science is an area of scholarship involving principles for data collection, storage, integration, analysis, inference, communication, and ethics in the context of the ubiquitous collection of massive data sets that have emerged in recent years. The field draws from a number of existing fields, including information technology, computer science, statistics, mathematics, and business analytics. However, core data science concepts are not being conveyed by mainstream training in any single other field because data science is not reducible to any of the preexisting fields.[2] Data science is an emerging and important technique in astronomy, but not in traditional astronomy or many branches of modern theoretical astrophysics.

One of the hallmarks of data science is that it outward-looking, engaging richly with multiple domains of application, including astronomy. In response to the university's strategic plan and in recognition of the interdisciplinary and outward-looking nature of data science, the Departments of Computer Science, Mathematics, Statistics, the Gies College of Business, and the I-School collaborated to develop a

[2] This paragraph adapted from p. 7 of *Data Science for Undergraduates: Opportunities and Options*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25104

framework for Astronomy & Data Science majors, enabling students to learn the principles of data science while engaging deeply with Astronomy.

In the Astronomy & Data Science program, the Astronomy Department offers coursework and advising in Astronomy; Computer Science, Mathematics, Statistics, and the i-School offer a core framework of courses and advising in data science; and the Astronomy program provides coursework and independent work/research experiences that integrate Astronomy and data science. We have a unique opportunity to meld astronomy research with Data Science due to the boom in Astronomy large surveys.

The degree program differs from other undergraduate degree programs in data science because it provides the student with substantial exposure to data science and to Scholarship in Astronomy, especially cutting-edge large surveys. It differs from the CS & Astronomy degree because the focus beyond Astronomy is in data science, which overlaps with but is distinct from computer science.

University of Illinois
University of Illinois' mission: The University of Illinois will transform lives and serve society by education, creating knowledge and putting knowledge to work on a large scale and with excellence.

2) Briefly describe how this program will support the University's mission, focus and/or current priorities. Demonstrate the program's consistency with and centrality to that mission.

The university continually examines its educational programs to respond to emerging student demand, societal need, and economic opportunity. Data science has rapidly emerged as a field for which there is broad-based demand across many areas of economic activity and across many fields of scholarship. For example, astronomy is preparing for a tsunami of data with the new and upcoming surveys. We need students trained in how to use these data in Astronomy to best leverage our participation. The university recognized the general need in its 2018 Strategic Plan *The Next 150,* which called on the to "[p]rovide all Illinois students the opportunity to have a meaningful exposure to data science." The degree program proposed here is part of that response.

State of Illinois
The Public Agenda for Illinois Higher Education is a planning blueprint for the State of Illinois to direct state policies and resources to the higher education and career needs of Illinois residents and to address the current and future economic needs of the state.

3) Indicate which of the following goals of the Illinois Board of Higher Education's Strategic Initiative are supported by this program: (choose all that apply)

X Educational Attainment - increase educational attainment to match the best-performing states.

College Affordability - ensure college affordability for students, families, and taxpayers

X High Quality Credentials to Meet Economic Demand - Increase the number of high-quality post-secondary credentials to meet the demands of the economy and an increasingly global society.

X Integration of Educational, Research and Innovation Assets - Better integrate Illinois' educational, research and innovation assets to meet economic needs of the state and its regions.

4) Describe how the proposed program supports the goals above:

We have a unique opportunity to meld astronomy research with Data Science due to the boom in Astronomy large surveys, providing students direct access to large datasets that vary with time. With Illinois and the US heavily engaged in these large astronomical surveys, this training will easily address the above goals. The data science taught in the courses, integrated with modern astronomy research, will provide essential training for our students. This type of training will increase educational attainment for our students and prepare them for high demand positions (already many of our graduates are accepting jobs in data science and this major will increase this trend). Astronomy driven surveys and astronomy trained students are already bringing jobs to Illinois, and we hope that with this new major the future will be as bright as the stars.

ADMISSION REQUIREMENTS

1) Desired admissions term: *For LAS units, a fall semester effective term for all curricula will be requested, please indicate the proposed year*

Fall 2022

2) Provide a brief description of the admission requirements for this program. Where relevant, include information about licensure requirements, student background checks, and admission requirements for transfer students.

Same requirements for the existing CS & Astronomy degree, which means the requirements are handled at the campus level.

3) Describe how critical academic functions such as admissions and student advising are managed.

Admissions is managed through campus. The Departments of Statistics and Computer Science and the i-School will provide advising for the data science portion of the degree program. Astronomy advising will be done by the Astronomy advisor.

ENROLLMENT

1) Number of students in program estimates-- Based on the CS & Astronomy major, we expect ~5 students per year.

Year 1 estimate: 5

Year 5 estimate (or when fully implemented): 20

2) Estimated Annual Number of Degrees Awarded (degrees, majors and concentrations ONLY)

Year 1: 0

Year 5 (or when fully implemented): 5

3) What is the matriculation term for this program? Fall

4) What is the typical time to completion of this program? 4 years

5) What are the minimum Total Credit Hours required for this program? 60 hours

6) Delivery Method, what is the program's primary delivery method? Face to Face

BUDGET

1) Will the program or revision require staffing (faculty, advisors, etc.) beyond what is currently available? If yes, please describe.

No.

2) Please provide any additional budget information needed to effectively evaluate the proposal.

None.

RESOURCE IMPLICATIONS

1) Facilities- Will the program require new or additional facilities or significant improvements to already existing facilities?
No.

2) Technology- Will the program need additional technology beyond what is currently available for the unit?
No. The technology resources for the data science portion are already available in the departments supporting the data science core.

3) Non-Technical Resources- Will the program require additional supplies, services or equipment (non-technical)?
No

RESOURCES

1) Faculty Resources: Please address the impact on faculty resources including any changes in numbers of faculty, class size, teaching loads, student-faculty ratios, etc. Describe how the unit will support student advising, including job placement and/or admission to advanced studies.

We suspect an increase in the core Astronomy courses, but we have the capacity for this. The Departments of Statistics and Computer Science and the i-School will provide advising for the data science portion of the degree program. Please contact representatives of those units to discuss advising needs in data science. For assistance, please contact Matthew Ando (mando@illinois.edu) or Kelly Ritter (ritterk@illinois.edu). Astronomy advising will be done by the Astronomy advisor.

2) Library Resources: Describe your proposal's impact on the University Library's resources, collections, and services. If necessary please consult with the appropriate disciplinary specialist within the University Library.

None

3) Instructional Resources: Will there be any reduction in other course offerings, programs or concentrations by your department as a result of this new program/proposed change? If yes, please describe.

None

4) Does this new program/proposed change result in the replacement of another program? If yes, please specify the program.

No

5) Does the program include any required or recommended subjects that are offered by other departments? If yes, please list the courses. Explain how these additional courses will be used by the program and provide letters of support from the departments.

The reference data science core includes the following courses:

Math 220 or 221* and 227 or 257 ; Stat 107 and 207 or 212; CS 277 and 307; IS 467 and 477

The explanation for these courses and the context for the interdisciplinary data science major is attached.

*We have excluded MATH 234 from the reference data science core due to requiring MATH 231 and MATH 241.

FINANCIAL RESOURCES

1) How does the unit intend to financially support this proposal?

No additional resources will be required.

2) Will the unit need to seek campus or other external resources? If yes, please provide a summary of the sources and an indication of the approved support.

No

3) Are you seeking a change in the tuition rate or differential for this program? (degrees, majors and concentrations ONLY)? If yes, please provide information on the request.

No

4) Is this program requesting self-supporting status? (degrees, majors and concentrations ONLY)? If yes, please explain.

No

MARKET DEMAND

1) What market indicators are driving this proposal? If similar programs exist in the state, describe how this program offers a unique opportunity for students.

The ubiquity of massive data sets in Astronomy and in other fields of the sciences and humanities has created enormous demand for data scientists across many domains of economic activity. Astronomy has seen an increase in enrollment of three-fold in the last ten years. Enrollment in the Statistics major has increased seven-fold in the last ten years, and other majors that involve data science have seen similar explosion in interest. But there is tremendous demand not only for coding-intensive data scientists but also for data scientists who can work collaboratively in application domains. Astronomy, with our "safe" and very large, yet open, datasets, are perfect for student learning and preparation for future data science positions.

2) What type of employment outlook should these graduate expect? Explain how the program will meet the needs of regional and state employers, including any state agencies, industries, research centers, or other educational institutions that expressly encourage the program's development.

The ubiquity of large data arising from an increasingly connected world means that data scientists and those who understand the human and policy implications of data are in demand in all domains of economic activity. Astronomy majors are already in demand for these types of positions. We need to take advantage of this and do our best to prepare our majors for the types of jobs that deal with large data and with statistical analysis of data, including machine learning.

3) What resources will be provided to assist students with job placement?

We will continue to push our students toward campus opportunities.

PROGRAM REGULATION & ASSESSMENT

1) **Briefly describe the plan to assess and improve student learning, including the program's learning objectives; when, how, and where these learning objectives will be assessed; what metrics will be used to signify student's achievement of the stated learning objectives; and the process to ensure assessment results are used to improve student learning.**

The current plan is for the Astronomy advisor to assess the learning objectives for our Astronomy & Data Science majors. Success in the advanced astronomy courses requires success in prerequisites, such as Physics courses. We carefully monitor student progress through the first two years of the major in the advising process, giving mentoring where necessary. During the third year, we evaluate the student's progress of in the ASTR 310 course through student assessments and projects to evaluate the impact of astronomy and data science. Finally, the research experience is assessed by the Director of Undergraduate Studies via the final project, required for the major. These project final reports will

provide an evaluation of the integration of data science and astronomy, allowing for systematic audits of the program overall.

2) Is the career/profession for graduates of this program regulated by the State of Illinois?

No

ACADEMIC CATALOG ENTRY

For the Degree of Bachelor of Science in College of Liberal Arts and Sciences

Astronomy + Data Science

E-mail: data-science@illinois.edu

Minimum required major and supporting course work normally equates to 64-67 hours

General education: Students must complete the Campus General Education requirements including the campus general education language requirement.

Twelve hours of 300 and 400-level courses must be taken on this campus.

Minimum hours required for graduation: 120 hours

Departmental distinction: To graduate with distinction requires a specified minimum grade point average in all Computer Science, Statistics, Information Science, and Mathematics courses listed below. A GPA of 3.25 is required for Distinction, 3.5 for High Distinction, and 3.75 for Highest Distinction.

Course	Title	Hours
Data Science Core		**28-31**
Mathematical Foundations		**6 – 8**
Calculus: One of MATH 220 or MATH 221		4 – 5
Linear Algebra: One of MATH 227, MATH 257, MATH 225, or MATH 415. MATH 227 or 257 is recommended.		2 – 4
Data Science Fundamentals		**12**
Data Science Discovery: STAT/CS/IS 107		4
Data Science Exploration: STAT 207		4
Modeling and Learning in Data Science: CS 307		4
Computational Fundamentals		**4**

Algorithms and Data Structures for Data Science: CS 277	4

Ethics and Responsibility in Data Science	**6**
Ethics and Policy for Data Science: IS 467	3
Data Management, Curation, and Reproducibility: IS 477	3

Course	Title	Hours
Coursework in Area of Specialization		**31 - 32**
University Physics: PHYS 211, 212, 213, 214		12
Calculus II & III: MATH 231, 241		7
Introduction to Astrophysics: ASTR 210		3
Computing in Astronomy: ASTR 310		3
Advanced Astronomy Courses (choose two of the following):		
ASTR 404, ASTR 405, ASTR 406, and ASTR 414		6-7

Research or Discovery Experience	**3**
ASTR 390 and/or ASTR 490	3

One of the most important skills a student will gain in an Astronomy +DS degree will be the ability to present astronomical data in meaningful ways. A research or discovery experience is as much as pillar of this degree program as both the data science core coursework (Part 1) and the coursework in Astronomy (Part 2).

This experience should be developed with an advisor before the end of a student's sophomore year and result in the creation of one or more artifacts documenting the experience. A minimum of 3 credit hours must be specifically designated to the preparation and the completion of the experience component.

Examples of possible experiences may include:

- A semester **study-abroad** with at one or more courses focused on discovery while attending the international institution.
- A multi-semester **capstone** experience within the student's area of specialization.
- A semester **co-op experience** outside Champaign-Urbana focused on a subject within the student's area of specialization.
- A multi-semester **undergraduate research experience** under the direction of Illinois faculty.
- A summer **NSF REU program** focused within a student's area of specialization.

TOTAL HOURS	**62-66**

ACADEMIC CATALOG ENTRY

For the Degree of Bachelor of Science in College of Liberal Arts and Sciences

Astronomy + Data Science

E-mail: data-science@illinois.edu

Minimum required major and supporting course work normally equates to 64-67 hours

General education: Students must complete the Campus General Education requirements including the campus general education language requirement.

Twelve hours of 300 and 400-level courses must be taken on this campus.

Minimum hours required for graduation: 120 hours

Departmental distinction: To graduate with distinction requires a specified minimum grade point average in all Computer Science, Statistics, Information Science, and Mathematics courses listed below. A GPA of 3.25 is required for Distinction, 3.5 for High Distinction, and 3.75 for Highest Distinction.

Course	Title	Hours
Required Data Science Core		**28-31**
Mathematical Foundations (6 – 8 hours)		
Calculus: One of MATH 220 or MATH 221		4 – 5
Linear Algebra: One of MATH 227, MATH 257, MATH 225, or MATH 415. (MATH 227 or 257 is recommended)		2 – 4
Data Science Fundamentals (11-12)		
STAT 107 (crosslisted with CS and IS 107)		4
STAT 207		3-4
CS 307		4
Computational Fundamentals (4 hours)		
CS 277		4
Ethics and Responsibility in Data Science (6 hours)		
IS 467		3
IS 477		3
Required Astronomy Coursework		**31 - 32**

PHYS 211, PHYS 212, PHYS 213, PHYS 214	4 4 2 2
MATH 231, MATH 241	3 4
ASTR 210	3
ASTR 310	3
Advanced Astronomy Courses - Select two courses from the following list: ASTR 404, ASTR 405, ASTR 406, ASTR 414	6-7

Research or Discovery Experience	**3**

ASTR 390 Ind Study and/or
ASTR 490 Senior Thesis

One of the most important skills a student will gain in an Astronomy +DS degree will be the ability to present astronomical data in meaningful ways. A research or discovery experience is as much as pillar of this degree program as both the data science core coursework (Part 1) and the coursework in Astronomy (Part 2).

This experience should be developed with an advisor before the end of a student's sophomore year and result in the creation of one or more artifacts documenting the experience. A minimum of 3 credit hours must be specifically designated to the preparation and the completion of the experience component.

Examples of possible experiences may include:

- A semester **study-abroad** with at one or more courses focused on discovery while attending the international institution.
- A multi-semester **capstone** experience within the student's area of specialization.
- A semester **co-op experience** outside Champaign-Urbana focused on a subject within the student's area of specialization.
- A multi-semester **undergraduate research experience** under the direction of Illinois faculty.
- A summer **NSF REU program** focused within a student's area of specialization.

TOTAL HOURS	**62-66**

ILLINOIS

SCHOOL OF INFORMATION SCIENCES
501 E. Daniel St., MC-493
Champaign, IL 61820-6211

March 4, 2021

Members of the Education Policy Committee:

I am writing to indicate our support for the following proposals:
Accountancy + Data Science
Astronomy + Data Science
Finance + Data Science
Information Sciences + Data Science

These programs will provide students across the university with the opportunity to study data science along with a disciplinary specialization. In particular, we support including IS 467 and IS 477. The School of Information Sciences will provide seats for all X + DS students in these courses starting in Fall 2021. Each course will be offered at least once per academic year.

Sincerely,

Dr. Emily Knox
Interim Associate Dean for Academic Affairs

ILLINOIS

MATHEMATICS

College of Liberal Arts & Sciences
273 Altgeld Hall, MC-382
1409 W. Green Street
Urbana, IL 61801 USA

March 8, 2021

To whom it may concern,

I am writing to indicate the support of the Department of Mathematics for the following proposals:

- Accountancy + Data Science
- Astronomy + Data Science
- Finance + Data Science
- Information Sciences + Data Science

These programs will provide students across the university with the opportunity to study data science along with a disciplinary specialization.

The Department of Mathematics supports the inclusion of the following courses in these proposals:

- MATH 220/221
- MATH 234
- MATH 227 or MATH 257

We will provide seats for X + DS students in these courses starting in Fall 2021. We intend to offer MATH 220 every semester, and MATH 221 and MATH 234 at least once per year. MATH 227 and MATH 257 are new courses, which we anticipate to offer for the first time during the 2021-2022 academic year. We intend to offer at least one of these courses each semester.

Sincerely,

Jeremy Tyson
Professor and Chair

UNIVERSITY OF ILLINOIS
AT URBANA–CHAMPAIGN

Department of Statistics
101 Illini Hall
725 South Wright Street
Champaign, IL 61820

October 5, 2020

To Whom It May Concern,

I am writing to indicate the support of the Department of Statistics for the following proposals:

- Accountancy + Data Science
- Astronomy + Data Science
- Finance + Data Science
- Information Sciences + Data Science

These programs will provide students across the university with the opportunity to study data science along with a disciplinary specialization.

The Department of Statistics supports including STAT/CS/IS 107 (to be co-taught by Statistics and Computer Science) and STAT/CS 207 or STAT 212 in the data science core curriculum. We will provide seats for X + DS students in these courses starting in Fall 2021. We intend to offer STAT/CS/IS 107 every semester and other courses at least once a year.

Sincerely,

Bo Li
Professor and Chair
Department of Statistics

telephone 217-333-2167 • *fax* 217-244-7190

ILLINOIS

DEPARTMENT OF COMPUTER SCIENCE
Thomas M. Siebel Center for Computer Science
201 N. Goodwin Ave.
Urbana, IL 61801-2302 USA

NANCY M. AMATO
Abel Bliss Professor and Head
2248 Siebel Center
namato@illinois.edu

March 4, 2021

To Whom It May Concern,

I am writing to indicate the support of the Department of Computer Science for the following proposals:

- Accountancy + Data Science
- Astronomy + Data Science
- Finance + Data Science
- Information Sciences + Data Science

These programs will provide students across the university with the opportunity to study data science along with a disciplinary specialization.

The Department of Computer Science supports including STAT/CS/IS 107 (to be co-taught by Statistics and Computer Science), CS 277, and CS/STAT 307 in the data science core curriculum. We will provide seats for X + DS students in these courses starting in Fall 2021. We intend to offer STAT/CS/IS 107 every semester and CS 277 and CS/STAT 307 at least once a year.

Sincerely,

Nancy M. Amato
Abel Bliss Professor and Head
Department of Computer Science