S.24-136

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MEMORANDUM

ATTENTION	Senate	**DATE**	September 19, 2024
FROM	Dilson Rassier, Provost and Vice-President Academic, and Chair, SCUP	**PAGES**	1/14
RE:	Full Program Proposal for the Certificate in Data Science in Physics (SCUP 24-35)		

At its meeting on September 11, 2024, SCUP reviewed and approved the full program proposal for the Certificate in Data Science in Physics in the Department of Physics within the Faculty of Science.

Motion: That Senate approve the full program proposal for the Certificate in Data Science in Physics in the Department of Physics within the Faculty of Science.

C: Nancy Hawkins, Associate Dean, Academic, Faculty of Science

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MEMORANDUM

ATTENTION	Senate Committee on University Priorities	**DATE**	August 2, 2024
FROM	Peter Hall, Chair Senate Committee on Undergraduate Studies	**PAGES**	1/1
RE:	Faculty of Science (SCUS 24-67)		

Action undertaken by the Senate Committee on Undergraduate Studies at its meeting of August 1, 2024, gives rise to the following recommendation:

Motion

That SCUP approves the Full Program Proposal for the Certificate of Data Science in Physics in the Department of Physics within the Faculty of Science.

The relevant documentation for review by SCUP is attached.

SIMON FRASER UNIVERSITY
ENGAGING THE WORLD

Certificate of Data Science in Physics

Full Program Proposal

April 1, 2024

Department of Physics

1 Executive Summary

a) An overview of the institution's history, mission, and academic goals:

Please provide a brief summary (1-2 paragraphs) that links the proposed program to the SFU's vision and mission (use and add to the boilerplate institution detail below):

As Canada's engaged university, Simon Fraser University is defined by its dynamic integration of innovative education, cutting-edge research and far-reaching community engagement. SFU was founded in 1965 with a mission to bring an interdisciplinary approach to learning, embrace bold initiatives, and engage with communities near and far. Today SFU is consistently ranked amongst Canada's top comprehensive universities and is one of the world's leading teaching and research institutions.

The proposed Certificate in Data Science in Physics will be a unique program in Canadian universities that continues SFU's tradition of innovative education. Many Physics graduates pursue data-driven careers in a wide range of fields, such as business and finance, health and medicine, material sciences, and engineering and planning. By combining physics principles and a physics-specific approach to critical thinking and problem solving with data science techniques, this certificate will provide students with the tools they need to contribute and excel in modern technological careers.

b) Credential to be awarded:

Certificate in Data Science in Physics

c) Location of program:

Burnaby: All courses in this program are existing courses offered at the Burnaby campus.

d) Faculty offering the proposed new program:

Department of Physics in the Faculty of Science

e) Anticipated program start date:

Fall 2025

f) Anticipated completion time:

Students will be able to complete the certificate within a normal undergraduate degree.

g) Summary of the proposed program

- **Aims, goals, and objectives:**

This certificate will showcase Physics students' experience with data science to prospective employers through formal evidence of this training, which will increase graduates' employability.

In addition to physics content knowledge, Physics graduates are known for their problem-solving abilities, mathematical literacy, critical thinking, modeling skills, and adeptness with handling data. Many go on to work in high technology careers at the interface of physical science, data science, modeling, and programming. The goal of this certificate is to add formal interdisciplinary training in data science methods to the data acquisition, analysis, and interpretation skills already present in a Physics degree.

- **Contribution to the mandate and strategic plan of the institution:**

This certificate addresses several of SFU's strategic research goals, especially enhancing our world through technology. Many careers pursued by graduates will speak to other goals as well, such as using physics training backed by data science to contribute to health and sustainability research. The certificate is also well centered in Big Data. Students completing this certificate will be prepared to contribute in these important areas. It is expected that these opportunities will increase enrollment, attract well-motivated students, and leverage our research strengths to compete for the best students.

- **Linkages between program outcomes and curriculum design:**

The goal of the certificate is for students to gain formal statistics and data analysis skills in addition to experimental design and techniques for collecting and analyzing real-world data from physics experiments. Students obtain these experimental skills from two key Physics lab courses - PHYS 233 and 332W. They also supplement these courses with a further PHYS elective course selected from a list of experimental, observational, computational, and theoretical courses that include data manipulation and statistics. The Data Science training in the certificate starts with STAT 270, a foundational formal course in probability and statistics course. Students then take core Data Science courses STAT 240, 302, and 452 to gain skills in statistics, inferences and hypothesis testing, and representation and manipulation of data sets. Overall, the curriculum ensures that students develop both theoretical knowledge and practical skills necessary for applying quantitative approaches to large data sets in a wide range of interdisciplinary careers.

- **Potential areas/sectors of employment for graduates or opportunities for further study:**

Graduates with the proposed certificate will find employment opportunities across various sectors, including research institutions, technology companies, finance,

healthcare, energy, government, and policy analysis. Further educational options include pursuing advanced degrees in data science, physics, or related fields.

- **Delivery methods:**

It will be based on the existing courses at SFU, which are all delivered face-to-face in standard lecture, lab, and tutorial environments.

- **Program strengths:**

This certificate is interdisciplinary and provides Physics students with the skills needed for modern careers in many technology fields, most of which require some form of programming, modeling, and data science experience. It leverages the parallel approaches to data analysis in Physics and Data Science programs to combine theoretical foundations with experience working with real-world data to provide students with a unique set of skills and experience suitable for a wide array of modern careers.

- **Level of support and recognition:**

Provide a brief explanation of the nature of the consultations that have occurred in the development of this program. Summarize comments received from other post-secondary institutions, potential employers, any regulatory or professional bodies where applicable, advisory committees, and experts in the field of study. In the appendices, attach any supporting documents.

Extensive consultation has occurred between the Physics and Statistics Departments to develop a certificate that provides students with important skills acquired in courses that can be successfully completed, given the interdisciplinary nature of the program. There are no formal regulatory bodies for this type of credential. However, as highlighted by webinars and career materials produced by the American Physical Society, in an environment where jobseekers for technical careers increasingly find their CVs processed by artificial intelligence programs before making the cut to interviews, formal documentation of analysis skills is increasingly important for Physics students seeking these careers. In addition to the critical skills themselves, this certificate would serve as a formal credential signifying graduates' abilities and training.

- **Related programs:**

Many major Canadian universities offer forms of Applied Physics and "Physics and Computer Science" degrees, and many also offer some form of Data Science degree or certificate; however, to the best of our knowledge, no Canadian schools offer this unique combination of data science and physics. Internationally, a small number of universities offer "data science and physics" degrees (Univ. of Birmingham, Keele Univ.) or a physics concentration within a data science degree (Univ. of Oregon). Given the large number of Physics graduates that proceed to

careers in data science, it is surprising there are not more formal credentials, and the proposed certificate will give our students an advantage in seeking such careers.

h) Contact information:

Jeff McGuirk, Assoc. Prof. and Undergrad. Chair in Physics,
778-782-3158
jmcguirk@sfu.ca

2 Credential Recognition and Nomenclature

2.1 Post-secondary recognition

Students graduating with a Data Science in Physics Certificate in addition to a B.Sc. in a Physics program would be extremely competitive for graduate school in Physics, in particular in experimental, observational, or computational physics areas. This certificate is a formal indication that their training goes beyond core physics courses and includes important specialized courses in data manipulation, analysis, and visualization for students wishing to pursue further degrees in these areas.

2.2 Industry/employer recognition

Where applicable, describe consultations undertaken to ensure the credential and learning outcomes will be recognized and meet the standards of industry/employers and regulatory, licensing or credentialing bodies. In the Appendices, provide current requirements or standards of those bodies and any copies of letters of recognition.

As mentioned above, there is no formal licensing or regulating body for a certificate in Data Science in Physics. However, in a series of American Physical Society webinars hosted by data science industry professionals with physics backgrounds, it was recommended that Physics students pursuing data science careers should have data science courses on their transcripts to indicate training beyond the standard physics training with real-world data, so as to elevate their applications. The proposed certificate goes beyond this and adds a credential that indicates students have more extensive training through completing a series of data science and physics courses. Students with such a certificate would be well poised to pursue a range of technical careers.

3 Curriculum/Program Content

3.1 Program structure

Describe in detail the program structure (e.g. length of program, number of units, requirements, options, methods of evaluation etc.).

The certificate pairs formal statistics and data analysis skills (12 units) with experimental design and techniques for collecting and analyzing real-world data from physics courses (10 units). Students may complete the certificate while completing a degree in Physics, no ramp-up time is anticipated beyond initial advertisement of the certificate.

The data science training in the certificate begins with STAT 270, a foundational formal course in probability and statistics course. Students then take core Data Science courses STAT 240, 302, and 452 to gain skills in statistics, inferences and hypothesis testing, and representation and manipulation of data sets. Students apply these concepts and obtain experimental skills in two key Physics lab courses, PHYS 233 and 332W, which both have a heavy focus on experimental design, data analysis and data interpretation based on statistical techniques. These core Physics courses are supplemented with a further PHYS elective selected from a list of experimental, observational, computational, and theoretical courses that include data manipulation and statistics.

Evaluation in all courses will be performed in standard ways, based on a blend of homework assignments, exams, written reports, and small projects in some cases.

3.2 Core courses

REQUIRED COURSES:

PHYS 233 - Physics Laboratory III (3) - Statistical data analysis, experimental design and scientific communication, studied in the context of experiments spanning a range of physical systems. Prerequisite: PHYS 133 or PHYS 141 or ENSC 120, with a minimum grade of C-. Recommended Prerequisite: CMPT 120.

PHYS 332W - Advanced Physics Laboratory I (4) - Experiments investigating a range of physical phenomena such as Brownian motion, molecular order, chaotic dynamics, Doppler broadening of stellar spectra, and biophysical forces using techniques such as interference, optical trapping, and spectroscopy. Attention will also be given to more general skills, including experimental design, operating and troubleshooting experimental equipment, modeling of experimental results, data analysis, and the presentation of experimental results. Biological Physics students will do a selected set of experiments. Prerequisite: PHYS 233; PHYS 285 or CHEM 260; both with a minimum grade of C-. Writing.

STAT 240 - Introduction to Data Science (3) - Introduction to modern tools and methods for data acquisition, management, and visualization capable of scaling to Big Data. Prerequisite: One of STAT 201, STAT 203, STAT 205, STAT 270, BUS 232, or ECON 233, and one of CMPT 102, CMPT 120, CMPT 125, CMPT 128, CMPT 129, CMPT 130, all with a minimum grade of C- or permission of the instructor. STAT 260 is also recommended.

STAT 270 - Introduction to Probability and Statistics (3) - Basic laws of probability, sample distributions. Introduction to statistical inference and applications. Prerequisite: or Corequisite: MATH 152 or 155 or 158, with a minimum grade of C-. Students wishing an intuitive appreciation of a broad range of statistical strategies may wish to take STAT 100 first.

STAT 302 - Analysis of Experimental and Observational Data (3) - The standard techniques of multiple regression analysis, analysis of variance, and analysis of covariance, and their role in observational and experimental studies. This course may not be used to satisfy the upper division requirements of the following programs: statistics major, statistics honours, actuarial science major, and actuarial science honours. Prerequisite: One of STAT 201, STAT 203, STAT 205, STAT 270, BUS 232, or ECON 233, with a minimum grade of C-. Students who have taken STAT 350 first may not then take the course for further credit.

STAT 452 - Statistical Learning and Prediction (3) - An introduction to the essential modern supervised and unsupervised statistical learning methods. Topics include review of linear regression, classification, statistical error measurement, flexible regression and classification methods, clustering and dimension reduction. Prerequisite: STAT 302 or STAT 305 or STAT 350 or ECON 333 or equivalent, with a minimum grade of C-.

ELECTIVE COURSES:

PHYS 234 - Physics Laboratory IV (3) - Introduction to modern techniques in experimental physics, including computer-aided data acquisition, electronics, control theory, and statistical data analysis. Prerequisite: PHYS 233 and PHYS 255, both with a minimum grade of C-. Students with credit for PHYS 231 may not take this course for further credit.

PHYS 391 - Introduction to Observational Astrophysics (3) - Hands-on introduction to observational astronomy including the astrophysics of stellar clusters, galaxies, nebulae, and the expanding universe; calculation of the conditions for observing target objects; and analysis of photometric and spectroscopic data with Python. Data will be acquired using the Trottier Observatory, weather permitting, otherwise, archival data will be used. Prerequisite: PHYS 233 or equivalent, with a minimum grade of C-. Recommended Prerequisite: CMPT 120 or equivalent.

PHYS 395 - Computational Physics (3) - Computer-based approaches to solving complex physical problems. Includes topics such as Monte-Carlo and molecular dynamics techniques applied to thermal properties of materials; dynamical behavior of systems, including chaotic motion; methods for ground state determination and optimization, including Newton-Raphson, simulated annealing, neural nets, and genetic algorithms: symplectic methods; and analysis of numerical data. Prerequisite: MATH 260 or MATH 310; PHYS 255; CMPT 120 or equivalent. All prerequisite courses require a minimum grade of C-.

PHYS 416 - Introduction to Quantum Information Science (3) - Includes topics such as qubits, density matrices, mixed states, entanglement, basic quantum algorithms, quantum cryptography, computational models and complexity, introductory quantum error correction, and applications. Prerequisite: PHYS 385; PHYS 384 or both MATH 314 and MATH 419, or equivalent. All prerequisite courses require a minimum grade of C-.

PHYS 445 - Statistical Physics (3) - Postulates of statistical mechanics, partition functions, applications to gases, paramagnetism and equilibrium. Quantum statistics and applications. Prerequisite: PHYS 344 or CHEM 360, with a minimum grade of C-. Recommended: PHYS 385.

3.3 Existing and new courses

No new courses are required. Existing courses are detailed in Section 3.2.

3.4 Curriculum and program goals

What are the educational goals of this program and how are they achieved by the courses and the curriculum structure? Describe how the learning environment and methodologies will help achieve the intended outcomes for this program.

Upon completion of a Certificate of Data Science in Physics, students will be able to

- Demonstrate proficiency in analyzing complex datasets using statistical methods, machine learning techniques, and data visualization tools, with a focus on applications in physics research and experimentation. (Data analysis proficiency)
- Integrate principles from physics with data science techniques to solve real-world problems, such as modeling physical systems, analyzing experimental data, and making predictions. (Integration of physics principles and data science techniques)
- Use computers to manipulate data, implement algorithms, and develop data-driven solutions using languages such as python or R. (Programming skills)
- Design and implement experiments to generate high-quality data for analysis. (Experimental design)
- Effectively communicate findings and insights derived from data analysis to both technical and non-technical audiences, and collaborate with interdisciplinary teams including physicists, data scientists, and others. (Communication)

3.5 Work experience/field/practicum placement

N/a

4 Program Resources

4.1 Target audience and enrolment plan

As students may complete the certificate while completing a degree in Physics, no ramp-up time is anticipated beyond initial advertisement of the certificate. An estimated 5-10 students/year are anticipated. Modest student numbers present no sustainability issues, as all courses in the certificate are already routinely offered.

4.2 Resources

No new resources are required, nor will any be diverted from other areas. All courses are currently regularly offered at SFU, and anticipated additional enrolments from the proposed Certificate program can be accommodated without creating additional sections.

5 Program Review and Academic/Administrative Oversight

Indicate plans for ensuring adequate depth and breadth of ongoing review and evaluation once the program has been implemented (regular program reviews are mandated by Senate on a 7-year cycle). If applicable, describe how membership on advisory committees for this program will be maintained to ensure that the program will remain current in future years. If any external accreditation is required, explain the evaluation cycle.

The program will be assessed primarily by the success of students – through completion of the courses within the certificate, numbers of students completing the certificate itself, and in their success in finding relevant careers following completion of the certificate. Alumni tracking will be important for obtaining this data. No accrediting bodies are involved.

6 Program Consultation

Detail the timeline and nature of the consultations that have occurred within the university and externally with students, program advisory committees, other BC post-secondary institutions and institutions outside of BC, professional associations, employers, etc. Attach any documents (emails, letters) in the Appendices.

Significant consultation has occurred over approximately 3 years between the Physics and Statistics Departments, including input by both Chairs, Undergraduate Chairs, the Data Science program head, and the Physics Undergraduate Curriculum Committee. Additionally, need for and design of the program was informed by webinars and other materials produced by the American Physical Society, which provides career information and statistics to Physics students and Departments.

7 Evidence of Student Interest and Labour Market Demand

Provide evidence supporting the expected student interest in this program, both domestic and international. What is the industry/employment demand for students who obtain this credential? What occupations/careers will graduates be able to compete for in the job market? (See the occupation resource links in the NOI template.) Update and attach any student survey results and occupational data and documentation from the Notice of Intent in the Appendices.

In 2019, LinkedIn named data science as the most promising career path for new graduates, with over 50% year-over-year growth. Additionally, data science is consistently ranked as one of the most satisfying career paths on Glass Door.

Physics graduates have been increasingly pursuing careers in data science, and they are sought by employers for their skills and experience working with real-world data sets. This trend is seen locally and more widely across North America. A significant number of undergraduate and graduate Physics students from SFU pursue careers in data science or in ancillary areas that benefit from data science training, as determined by alumni tracking. More broadly, the American Physical Society (APS) offers a growing number of resources targeted at this path, including the APS page on Data Science in Industry, and several webinars on preparing students for data science careers aimed at both students and instructors. Furthermore, students pursuing some of the most popular subfields of physics, such as astronomy, particle physics, biological physics, and computational physics, would greatly benefit from additional experience with data science and big data techniques in their academic work.

8 Appendices

8.1 Calendar entry

A complete proposed Calendar entry must be attached.

8.2 New Courses

Attach new course approval forms, sample course outlines, and library reviews for each course.

8.3 Market analysis – student interest and labour market demand

Include any data, student surveys, and letters of support from industry, employers, or accrediting bodies, that provide evidence of student and labour demand.

8.4 Consultation comments and letters of support

Attach any written endorsements or comments, from both internal and external sources.

8.5 Resources

Include any supportive memos indicating that sufficient space and other resources (such as confirmation from the Dean's Office, library reports, etc.) are available for the program.

8.6 Financial plan (only if additional resources required)

Outline the initial start-up costs, such as curriculum development and online design, as well as anticipated costs in offering the program (instructional salaries and benefits, administrative overhead, student services, and online support).

8.7 Abbreviated curriculum vitae for faculty

(needed only for new programs requiring Ministry of Advanced Education final approval) Include a CV for each faculty member in the program. In the case of cross-disciplinary programs, include a CV for each member of the steering committee and for faculty members likely to be teaching core courses. It is strongly suggested that short (e.g. 2 pages), standardized CVs be submitted, providing brief information on: current position; credentials; research interests; publications, grants and graduate supervision over a defined period (e.g. last seven years).

Data Science in Physics

CERTIFICATE

This program is intended for students who wish to apply statistical analysis methods with Physics data. Students completing this certificate will gain an appreciation for the collection and processing of experimental data, as well as statistical and computational tools necessary to analyze and visualize data.

Minimum Grade Requirement

To enroll in all courses, a student must obtain a grade of C- or better in each prerequisite course. Students must maintain a cumulative GPA of at least 2.0 in courses required for the certificate.

Program Requirements

Units applied to this certificate may be applied also to major or minor programs of a Bachelor's degree but may not be applied to another certificate or diploma.

Students complete 22 units as specified below.

Complete all of:

- PHYS 233 Physics Laboratory III (3)
- PHYS 332W Advanced Physics Laboratory I (4)
- STAT 240 Introduction to Data Science (3)
- STAT 270 Introduction to Probability and Statistics (3)
- STAT 302 Analysis of Experimental and Observational Data (3)
- STAT 452 Statistical Learning and Prediction (3)

And one of:

- PHYS 234 Physics Laboratory IV (3)
- PHYS 391 Introduction to Observational Astrophysics (3)
- PHYS 395 Computational Physics (3)
- PHYS 416 Introduction to Quantum Information Science (3)
- PHYS 445 Statistical Mechanics (3)