

THE GRADUATE SCHOOL - UNIVERSITY OF RHODE ISLAND
NEW PROGRAM REPORT FROM THE GRADUATE COUNCIL TO THE
FACULTY SENATE
CURRICULAR REPORT 2019-2020-10; 6 April 2020

At Meeting No. 531 held on 06 April 2020, the Graduate Council approved the attached proposal that is now submitted to the Faculty Senate.

SECTION I
ABSTRACT AND BACKGROUND INFORMATION

ABSTRACT (modified from proposal)

The Graduate Council approved a proposal from the College of Arts and Sciences to create a ***new MS in Quantum Computing***. The MS in Quantum Computing is designed to build on the Physics Department's strengths in quantum mechanics, optics and nanophysics to prepare graduates to become productive, applied scientists in the quest to make quantum computing a viable complement to classical computing. Specifically, the proposed program generates research and scholarly activity in science and technology that spans multiple domains. Intersections with Computer Science, Mathematics, Chemistry and Engineering will increase research collaborations across disciplines for undergraduate and graduate students. At the same time, this program will build partnerships with corporations and outside institutions. An internship is required and the interaction between students and adjuncts from industry will help ensure that students are prepared to pursue either further academic research or non-academic employment after graduation.

BACKGROUND (modified from proposal)

Researchers are currently on the threshold of being able to overcome the inherent fragility of quantum computation. At the same time, advances in quantum circuitry and algorithms are being proposed. We are partnering with industrial firms and institutes to ensure that our graduates have the required foundation for employment in this rapidly advancing field. The global presence of URI will be expanded because there are few academic institutions in the US that offer degrees in quantum information, and only a couple that offer an MS in quantum computing. The United States is currently lacking academic institutions to train professionals for jobs in quantum information science.

SECTION II
RECOMMENDATION

The Graduate Council approved the proposal to create a ***new MS in Quantum Computing*** at its Meeting No. 531 held on 06 April 2020, and forwards it to the Faculty Senate with a recommendation for approval.

**Full Proposal Form
For All Programs including Certificates
Requiring New Funding or Resources**

A Proposal for: MS in Quantum Computing

Date: Fall 2019

A. PROGRAM INFORMATION

A1. Name of institution: University of Rhode Island

A2. Name of department, division, school or college

Department: Physics

College: Arts and Sciences

A3. Title of proposed program and Classification of Instructional Programs [\(CIP\) code](#)

Program title: MS in Quantum Computing

Classification code (CIP): 40.0899

A4. Intended initiation date of program change. Include anticipated date for granting first degrees or certificates, if appropriate.

Initiation date: Fall 2020

First degree date: Spring 2022

A5. Intended location of the program: URI Kingston

A6. Description of institutional review and approval process

	<u>Approval Date</u>
Department	18 December 2019
College	1/13/20
CAC/Graduate Council	4/6/20
Faculty Senate	
President of the University	

A7. Summary description of proposed program (not to exceed 2 pages)

The MS in Quantum Computing is designed to build on the Physics Department's strengths in quantum mechanics, optics and nanophysics to prepare graduates to become productive, applied scientists in the quest to make quantum computing a viable complement to classical computing. Researchers are currently on the threshold of being able to overcome the inherent fragility of quantum computation. At the same time,

advances in quantum circuitry and algorithms are being proposed. We are partnering with industrial firms and institutes to ensure that our graduates have the required foundation for employment in this rapidly advancing field. We have commitments from the Dean to prioritize hiring tenure track faculty in this area and to fund part time faculty who work in the field of quantum computing to add leading edge professional experience to our program. We also have enthusiastic support from a major quantum computing company to sponsor internships.

The proposed degree program is well aligned with the University's Strategic Academic Plan. Specifically, the proposed program generates research and scholarly activity in science and technology that spans multiple domains (Goal 2 Strategy1, Action1). Intersections with Computer Science, Mathematics, Chemistry and Engineering will increase research collaborations across disciplines for undergraduate and graduate students (Goal 1, Strategy 3, Action 1). At the same time, this program will build partnerships with corporations and outside institutions (Goal 2, Strategy 3, Action 1). An internship is required and the interaction between students and adjuncts from industry will help ensure that our students are prepared to pursue either further academic research or non-academic employment after graduation (Goal 1, Strategy 2, Actions 2,3,4). We also intend to offer a 5-year BS/MS degree program (not an ABM) and attract some of the best undergraduates nationally. This program will not only help recruit additional undergraduates to physics but will also increase our graduate enrollment (Goal2, Strategy 2, Action 4). Moreover, Quantum Computing is a global initiative, and we intend for this program to advance the profile and prestige of URI and attract international collaborators (Goal 2, Strategy 5 & Goal 3, Strategy 1). The global presence of URI will be expanded because there are few academic institutions in the US that offer degrees in quantum information, and only a couple that offer an MS in quantum computing (Goal3, Strategy1). The United States is currently lacking academic institutions to train professionals for jobs in quantum information science. Our Quantum Computing MS also aligns closely with the strategic goals of the National Quantum Initiative Act: (a) to expand the number of researchers, educators and students; b) to promote the development of multidisciplinary curricula and research opportunities; c) to address basic research gaps; d) to promote further development of facilities; and e) to stimulate research in quantum based technologies. These goals parallel the themes of URI's Strategic Academic Plan and Mission mentioned above.

A8. Signature of the President

David M. Dooley

A9. Person to contact during the proposal review

Name: Leonard M. Kahn
Title: Professor and Chair, Physics
Phone: 874-2053
Email: lenkahn@uri.edu

Name: Donald DeHayes
Title: Provost/VP Academic Affairs
Phone: 401-874-4410
Email: Officeofprovost@etal.uri.edu

A10. List and attach any signed agreements for any cooperative arrangements made with other institutions/agencies or private companies in support of the program.

See Appendix 1: Letter from Christopher Savoie, Founder and CEO Zapata Computing

B. RATIONALE: There should be a demonstrable need for the program.

B1. State the program objectives.

The objective of the program is to fill the national need for physicists trained in Quantum Computing. The goals of the National Quantum Initiative Act are to: (a) to expand the number of researchers, educators and students; b) to promote the development of multidisciplinary curricula and research opportunities; c) to address basic research gaps; d) to promote further development of facilities; and e) to stimulate research in quantum-based technologies. Our proposed MS program will address each of these concerns by a) offering research and education opportunities to graduate and undergraduate students; b) interacting with Mathematics, Computer Science, Chemistry and Engineering to give students a well-balanced education; c) partnering with industry to identify those areas of most productive research; d) developing an infrastructure to advance our research; and e) encourage and recruit students into the growing area of Quantum Computing.

B2. Explain and quantify the needs addressed by this program, and present evidence that the program fulfills these needs.

a. What is the economic need and workforce data related to the program?

While there are abundant interests and investments in Quantum Computing from the major technology companies (e.g. Microsoft, Google, IBM...), there is currently only one university offering a graduate degree in Quantum Computing (Wisconsin). Most researchers must switch from previous work to begin working in this field after graduation. NSF recently had an RFP to encourage universities to begin graduate programs in order to increase the number of trained researchers and to close the perceived gap in personnel with other countries. Quantum Computing has the potential to revolutionize the way computation is carried out and the economic benefits will be substantial.

b. Provide information on jobs available as a result of successfully completing the certificate or degree: job titles, job outlook/growth, and salaries.

An MS degree in Quantum Computing that includes industrial experience will open doors for a multitude of jobs and academic opportunities. Consultants from outside companies are strongly supporting this program with the vision of being

able to hire our graduates. A scan of employment opportunities for a person with a background in quantum information: Application Scientist (with a background in quantum computing)- Zurich Instruments, Quantum Computing Theorist- Raytheon, Quantum Computing Experimentalist – Raytheon, Research Scientist: Quantum Computation – IBM, Quantum Computing Researcher-IBM, Quantum Software Development – Microsoft, Senior Quantum Engineer- Rigetti Quantum Computing, Quantum Compiler Developer- Intel. The number of such jobs posted is well over 100. Having a degree in Quantum Computing with industrial experience, will position our graduates for jobs, with anticipated starting salaries ranging from \$80K -\$120K (based on a review of job offerings in the industrial sector).

B3. If an external advisory or steering committee was used to develop the program, identify committee members and their affiliations and describe the committee's role.

Chris Savoie – Zapata Computing, Cambridge

Bradley Rotter- Entanglement Institute, Newport

The advisory committee will be able to keep the program abreast of opportunities in the field of quantum computing (research, corporate funding initiatives, internship possibilities...), help students and graduates understand the marketplace for jobs, aid in recruitment of students and faculty, and, where appropriate, make suggestions for revision of courses and curriculum.

C. INSTITUTIONAL ROLE: The program should be clearly related to the published role and mission of the institution and be compatible with other programs and activities of the institution.

C1. Explain how the program is consistent with the published role and mission of the institution and how it is related to the institution's academic planning.

The proposed degree program is well aligned with the University's Strategic Academic Plan. Specifically, the proposed program generates research and scholarly activity in science and technology that spans multiple domains (Goal 2 Strategy1, Action1). Intersections with Computer Science, Mathematics, Chemistry and Engineering will increase research collaborations across disciplines for undergraduate and graduate students (Goal1, Strategy3, Action1). At the same time, this program will build partnerships with corporations and outside institutions (Goal 2, Strategy3, Action1). An internship is required and the interaction between students and adjuncts from industry will help ensure that our students are prepared to pursue either further academic research or non-academic employment after graduation (Goal 1, Strategy 2, Actions 2,3,4). We also intend to offer a 5-year BS/MS degree program (not an ABM) and attract some of the best undergraduates nationally. This program will not only help recruit additional undergraduates to physics but will also increase our graduate enrollment (Goal2, Strategy 2, Action4). Moreover, Quantum Computing is a global initiative, and we intend for this program to advance the profile and prestige of URI and attract

international collaborators (Goal 2, Strategy 5 & Goal 3, Strategy1). The global presence of URI will be expanded because there are few academic institutions in the US that offer degrees in quantum information, and only a couple that offer an MS in quantum computing (Goal3, Strategy1).

C2. Explain the relationship of the program to other programs offered by the institution.

This program will complement other programs on campus. The proposed MS program in Quantum Computing could serve as a foundation for PHD research in Physics. There is also significant overlap with Mathematics and Computer Science. We anticipate that our students will benefit greatly from courses in those departments, and their students might appreciate some of our courses.

See Appendix 2: Letters of support from Mathematics and Computer Science Departments

D. INTER-INSTITUTIONAL CONSIDERATIONS: The program should be consistent with all policies of the Council on Postsecondary Education pertaining to the coordination and collaboration between public institutions of higher education.

D1. List similar programs offered in the state and region and compare the objectives of similar programs. If similar programs exist, how is this program different or why is duplication necessary?

There are other physics departments in the state that offer graduate courses in quantum mechanics. To our knowledge there are no courses in Quantum Computing and no degree programs. URI has the only public graduate program in physics.

D2. Estimate the projected impact of program on other public higher education institutions in Rhode Island (e.g. loss of students or revenues), provide a rationale for the assumptions made in the projections, and indicate the manner in which the other public institutions were consulted in developing the projections. Have you communicated with other institutions about the development of this program and have any concerns been raised related to role, scope, and mission or duplication?

Since URI has the only public graduate program in physics, there is no impact on other public higher education institutions in Rhode Island.

D3. Using the format prescribed by the Council on Postsecondary Education, describe provisions for transfer students (into or out of the program) at other Rhode Island public institutions of higher education. Describe any transfer agreements with independent institutions. The institution must also submit either a Joint Admissions Agreement transition plan or the reason(s) the new program is not transferable (see [*Procedure for Strengthening the Articulation/Transfer Component of the Review Process for New Programs*](#)).

Since this is a graduate program, transfer agreements with other Rhode Island public institutions of higher education are not applicable.

D4. Describe any cooperative arrangements or affiliations with other institutions in establishing this program. (Signed copies of any agreements pertaining to use of faculty, library, equipment, and facilities should be attached.)

a. How does this program align to academic programs at other institutions?

This degree program has no counterpart at other institutions.

b. Are recipients of this credential accepted into programs at the next degree level without issue?

Graduates of this program would be admitted to PHD programs in Physics at URI and elsewhere.

c. How does this program of study interface with degree programs at the level below them?

We have developed a course map by which an incoming 1st year student could complete a BS in Physics and an MS in Quantum Computing with 5-years. Graduates with a BS in Physics would be eligible to apply to the proposed MS program.

D5. If external affiliations are required, identify providing agencies (indicate the status of any arrangements made and append letters of agreement, if appropriate).

N/A

D6. Indicate whether the program will be available to students under the New England Board of Higher Education's (NEBHE) Regional Student Program (RSP).

Because of the unique nature of this degree program, we eventually will be pursuing an option that will make it available under NEBHE -RSP.

E. PROGRAM: The program should meet a recognized educational need and be delivered in an appropriate mode.

E1. Prepare a typical curriculum display for one program cycle for each sub-major, specialty or option, including the following information: *See Appendix 3 for a curriculum map*

a. Name of courses, departments, and catalog numbers and brief descriptions for new courses, preferably as these will appear in the catalog.

MTH513 Linear Algebra

PHY510 Mathematical Methods 1

PHY610 Mathematical Methods 2

PHY525 Statistical Physics 1

PHY530 Electromagnetism 1

PHY570 Quantum Mechanics 1

PHY580 Condensed Matter 1

PHY591 Research Project

PHY670 Quantum Mechanics 2

PHY680 Condensed Matter 2

PHY575 Introduction to Quantum Computing

LEC: (3 credits) Qubits and their physical realization. Entanglement and Bell states. Quantum gates and circuits. Quantum algorithms: searches, factoring, Fourier transforms. Quantum information theory with applications to teleportation and cryptography. Physical applications.

PHY576 Advanced Quantum Computing

LEC: (3 credits) Advanced quantum circuit theory. Decoherence and density matrices. Error correction. Dense and superdense coding. Quantum tomography. Hardware.

PHY577 Quantum Computing Internship

LAB: (4 credits)

b. Are there specializations and/or tracks/options/sub-plans/concentrations?

There are no specializations.

If so, describe required courses in area of specialization or tracks/options/sub-plans/concentrations.

c. Course distribution requirements, if any, within program.

No course distribution requirements.

d. Total number of free electives available after specialization requirements are satisfied.

No free electives; although, depending on preparation, additional courses are available.

e. Total number of credits required for completion of program or for graduation. Present evidence that the program is of appropriate length as illustrated by conformity with appropriate accrediting agency standards, applicable industry standards, or other credible measure, and comparability of lengths with similar programs in the state or region.

38 credits are required for the MS degree. This is consistent with other MS programs in Physics and is equivalent to the only other MS in Quantum Computing currently in existence (U. Wisconsin).

This proposed MS degree is a non-thesis degree, with a comprehensive exam and a substantial paper.

f. Identify any courses that will be delivered or received by way of distance learning (refer to [*Policy on Distance Learning, Council on Postsecondary Education, State of Rhode Island and Providence Plantations*](#)).

No distance learning.

g. Is the program content guided by program-specific accreditation standards or other outside guidance?

No accreditation standards.

E2. Describe certification/licensing requirements, if any, for program graduates and the degree to which completion of the required course work meets said requirements. Indicate the agencies and timetables for graduates to meet those requirements.

Not applicable.

E3. Demonstrate that student learning is assessed based on clear statements of learning outcomes and expectations and provide an assessment plan.

*The program assessment plan for Quantum Computing, presented in **Appendix 4**, clearly defines the program goals, the student learning outcomes and the assessment timeline.*

- a. Include the learning goals (what students are expected to gain, achieve, know, or demonstrate by completion of the program) requirements for each program.
- b. Demonstrate that student learning is assessed based on clear statements of learning outcomes and expectations.
- c. Provide an assessment plan detailing what a student should know and be able to do at the end of the program and how the skills and knowledge will be assessed. Consult with the [Office of Student Learning, Outcomes Assessment, and Accreditation \(SLOAA\)](#) when preparing the [Learning Outcomes Assessment Plan](#) for student learning assessment. Following consultation, submit a final draft of the plan to the Chair of the [Learning Outcomes Oversight Committee](#) (LOOC) for approval by the full Learning Outcomes Oversight Committee.

F. FACULTY AND STAFF: The faculty and support staff for the program should be sufficient in number and demonstrate the knowledge, skills, and other attributes necessary to the success of the program.

F1. Describe the faculty who will be assigned to the program. Indicate total full-time equivalent (FTE) positions required for the program, the proportion of program faculty who will be in tenure-track positions, and whether faculty positions will be new positions or reassignment of existing positions. What are the minimal degree level and academic/technical field requirements and certifications required for teaching in this program?

The faculty involved teaching these courses includes current tenure track faculty, Teaching Professors, adjuncts from industrial firms, and anticipated new tenure track hires. Faculty at URI all have PhDs in physics or closely related fields. Adjuncts will have MS or PhDs in related fields.

F2. List anticipated support staff, the percent of their time to be spent in the program, and whether these are reassignments or new positions. Indicate total full-time equivalent (FTE) positions required for the program.

We anticipate minimal change in the role of the support staff. For the new courses 1 FTE is required for the program.

F3. Summarize the annual costs for faculty and support staff by indicating salaries and fringe benefits (adjusted for the proportion of time devoted to the program). Distinguish between existing resources and new resources. Specify in the narrative if resources are to be provided by more than one department. Include the salary and benefits information on the Rhode Island Office of Postsecondary Commissioner [budget form](https://www.riopc.edu/page/academic_program/) (https://www.riopc.edu/page/academic_program/)

See Appendix 5 for Budget Spreadsheet.

- G. STUDENTS:** The program should be designed to provide students with a course of study that will contribute to their intellectual, social, and economic well-being. Students selected should have the necessary potential and commitment to complete the program successfully.

- G1. Describe the potential students for the program and the primary source of students. Indicate the extent to which the program will attract new students or will draw students from existing programs and provide a specific rationale for these assumptions. For graduate programs, indicate which undergraduate programs would be a potential source of students.**

We intend to recruit students not only from physics majors nationally and internationally, but also by targeting talented students in high school. A 5-year BS Physics/ MS Quantum Computing should draw national recognition. Graduates of Applied Physics, Mathematics, Computer Science and Engineering programs will also be considered with the proviso that some additional course work will be required.

- G2. Estimate the proposed program size and provide projected annual full-time, part-time, and FTE enrollments for one complete cycle of the program. Provide a specific rationale for the assumptions made in the projections. Depending on the nature of the program, use the FTE or part-time estimates of enrollment on the Rhode Island Office of Postsecondary Commissioner [budget form](https://www.riopc.edu/page/academic_program/) (https://www.riopc.edu/page/academic_program/)**

See Appendix 5: Budget Spreadsheet.

- G3. Indicate how the institution provides programs and services designed to assist students in achieving their academic goals.**

The University creates a welcoming and nurturing environment for students. There are abundant opportunities for students to interact across disciplinary lines and to meet scholars from around the nation and the world. These opportunities encourage students to excel and reach their academic and career goals.

- G4. List the program admission and retention requirements for students. Provide descriptions of the specific criteria and methods used to assess students' ability to benefit from the program. Describe how satisfactory academic progress will be determined.**

Admission requirements will follow current practices for admission to the PHD program. We do not require the GRE General or Physics Exams. Students will be required to have a BS in Physics or a closely related field and have a grade of B or better in a rigorous quantum mechanics course. Students who successfully take advanced physics courses will be considered for admission as well. Students' retention will be determined by Graduate School guidelines as well as the successfully completing the 4 parts of the comprehensive exam.

- G5. Indicate available funds for assistantships, scholarships and fellowships. Include this information on the Rhode Island Office of Postsecondary Commissioner [budget form](https://www.riopc.edu/page/academic_program/) (https://www.riopc.edu/page/academic_program/)**

Teaching and/or research assistantships will be available on a competitive basis from the existing assistantships in the department.

H. ADMINISTRATION: Administrative oversight for the program should be sufficient to ensure quality.

H1. Indicate how the program will be administered and the degree to which this work will affect the administrative structure in which it is located.

This program will have some administrative work associated with its management. It is anticipated that the Chair and the Directors of the Physics Graduate Program will assume those responsibilities. If necessary, a director of Quantum Computing might be selected from our existing faculty.

H2. Indicate the titles of the persons who will have administrative responsibility for the program and the percent of time each will spend on the program.

Department Chair (5%) Directors of the Graduate Program (5%)

H3. Indicate additional annual administrative salaries and related costs to be associated with the program. Distinguish between existing resources and new resources.

Include this information on the Rhode Island Office of Postsecondary Commissioner [budget form](https://www.riopc.edu/page/academic_program/budget_form) (https://www.riopc.edu/page/academic_program/)

No new administrative salaries will be required.

I. INSTRUCTIONAL RESOURCES: The instructional resources should be sufficient in quantity, quality, and timeliness to support a successful program.

I1. Estimate the number and cost of relevant print, electronic, and other non-print library materials needed (and those available) for the program and compare with recommendations of national accrediting agencies.

No new library materials are needed.

I2. Identify and evaluate other instructional resources and instructional support equipment (such as computers, laboratory equipment, supplies, clinical space, internships, proctors) in terms of overall capability to satisfy the needs of the program. If these instructional resources are considered insufficient or if upgrading is necessary for the development of the program, the additional needs should be detailed and their cost estimated.

Internships are a required part of the program. We have commitments for these. See [Appendix 1](#) for letter of support from Christopher Savoie.

I3. Estimate annual expenditures for instructional resources. Distinguish between existing resources and new resources. The information should reflect the annual operation and maintenance of the instructional resources, recurrent costs and costs for necessary additions. Include this information on the Rhode Island Office of Postsecondary Commissioner [budget form](https://www.riopc.edu/page/academic_program/budget_form) (https://www.riopc.edu/page/academic_program/)

Annual expenditures for adjuncts will be approximately \$15K. See Appendix 6 for Dean's letter of support.

I4. Provide a [Library Impact Statement](#).

J. **FACILITIES AND CAPITAL EQUIPMENT:** Facilities and capital equipment should be sufficient in quantity, quality, and timeliness to support a successful program.

J1. Describe the facilities and capital equipment (e.g., classrooms, office space, laboratories, and telecommunications equipment) and assess the adequacy of these resources relative to the program and to the requirements of the American with Disabilities Act and state disability statutes.

No new facilities are presently envisioned for this program; however, if enrollment soars above current expectations office space for those students and additional computational facilities would be beneficial.

J2. If new or renovated facilities are necessary, explain in detail (e.g., requirements, costs, sources of revenue, and expected date of completion). Include this information on the Rhode Island Office of Postsecondary Commissioner [budget form](#) (https://www.riopc.edu/page/academic_program/

J3. Estimate the annual additional expenditures for new program facilities and capital equipment. Include this information on the Rhode Island Office of Postsecondary Commissioner [budget form](#) (https://www.riopc.edu/page/academic_program/

No additional expenditures are required for facilities or capital equipment.

J4. Indicate whether the needed facilities are included in the institution's master plan.
N/A

K. **FINANCIAL CONSIDERATIONS:** Projected revenues should be sufficient to support a successful program and must cover the estimated costs of the program.

See Appendix 5: Budget Spreadsheet.

K1. Expenditures for program initiation and annual operation should be estimated and displayed in the proposed budget. The summary should enable the reader to understand expenditures for a period representative of one full program cycle.

K2. Revenue estimates should be provided for a similar period of time. For a new program, the appropriateness and feasibility of instituting differential tuition and/or fees should be addressed.

NOTE: Excel budget forms (Rhode Island Office of Postsecondary Commissioner https://www.riopc.edu/page/academic_program/) are self-calculating.

K3. Describe how current institutional resources will be redeployed or extra institutional resources will be obtained to support the program (e.g., describe program eliminations, staff reallocations and/or external sources of monies).

L. EVALUATION: Appropriate criteria for evaluating the success of a program should be developed and used.

- L1. List the performance measures by which the institution plans to evaluate the program. Indicate the frequency of measurement and the personnel responsible for performance measurements. Describe provisions made for external evaluation, as appropriate.**

The success of the program is predicated on several components: a) number of students per entering class, b) retention of those students through the program, c) ability of our graduates to gain employment in the field of quantum computing or successfully pursue an advanced degree. These measurements will take place yearly and will be monitored by the department chair. The mentors for our internships will also provide feedback on the quality of our program.

- L2. Describe and quantify the program's criteria for success.**

The number of entering students is expected to reach an equilibrium floor of 5-8. A successful program should be able to retain 80% of entering students to completion of their degree. Of those who graduate, 80% should attain satisfactory employment or academic enrollment in a successful program.

- L3. If the proposed program is eligible for specialized accreditation, indicate name and address of the accrediting agency and a list of accreditation requirements. If specialized accreditation is available but not sought, indicate reasons.**

N/A

- L4. Describe the process that communicates the results of the program evaluation to appropriate institutional stakeholders and uses the outcomes for program improvement.**

The annual review of the department will detail the number of students who enter, complete and go on to success through the degree program. Feedback from students, faculty, industrial and institutional partners, the assessment protocol, as well as the dean's office will guide our path toward improvement of the program.



ZAPATA COMPUTING, INC.
100 FEDERAL STREET
20TH FLOOR
BOSTON, MA 02110

December 17, 2019

Dean Jeanette E. Riley
College of Arts and Sciences
The University of Rhode Island

Dear Dean Riley,

I am writing this letter in support of the proposed MS degree in Quantum Computing and the supporting courses being proposed by the Physics Department. The proposed MS program will attract some of the most talented physics graduate students in the country, if not internationally. There is presently a lack of programs offering this degree option, and the overwhelming demand for graduates by the major players, such as Google, Microsoft and IBM and by smaller companies is unmet by current graduates. Furthermore, this curriculum is being designed to allow a high school graduate to receive a BS in Physics and an MS in Quantum Computing in 5 years. This will be a significant attraction for outstanding high school graduates in the northeast and beyond. For URI to be at the forefront of this advancement at such a critical time could be transformative.

As we have discussed, I am sufficiently confident in the benefits of this MS Program in Quantum Computing, that I will support it by encouraging members of my company, Zapata Computing, to serve as adjunct faculty. In addition, Zapata will make summer internships available for qualified students, and I will encourage more companies to support these interns as well.

The MS in Quantum Computing is being proposed at a crucial time in the development of the field, and I committed to help making this degree program a major success.

Sincerely,

Christopher J. Savoie, Ph.D., J.D.
Founder and Chief Executive Officer
Zapata Computing
+1-617-850-2486 Mobile
cjs@zapatacomputing.com

Appendix 2: Letters of support from Mathematics and Computer Science.

Mathematics:

Hi, Leonard.

The proposed MS degree in Quantum Computing does not have a substantial overlap with our applied MS degree. Also, it does not appear that we would be competing for the same graduate students.

If the undergraduate students take all recommended courses, then they would be one or two courses short of getting a second major in math (BS:Applied Option or BA). Would you be interested in doing a track of recommended courses that would allow students to double major in math/physics B.S.? We have done something similar with a track of recommended courses with COB for a double major in finance and applied math degree http://www.math.uri.edu/wp-content/uploads/2019/02/CS_Math-Finance_BS.pdf This double major is very popular with the URI students interested in Actuarial sciences.

I sent your email around the department and below are some additional remarks about the list of courses.

1. Courses MTH 462 and MTH 418 run every two years. As of right now, MTH 462 is taught in falls of odd numbered years and MTH 418 in springs of odd numbered years.
2. This is the first time MTH 472 has been running in a long time, the department will need to think of its future.
3. MTH 513 is a theoretical course and even though it has no official pre-requisite, mathematical maturity is required. Students must be able to write proofs, or at least be willing to learn and pick up those skills as the class progresses.
4. CSC 440 requires CSC/MTH 447 and CSC 212 - the latter course does not seem as one of the required/recommended courses in the course roadmap. Moreover, if students want to take CSC 212, they must take CSC 211 and not CSC 201. Finally, CSC 544 requires CSC 440 as a pre-req.

best,
Jim

Computer Science:

Leonard,

We just had a faculty meeting and we discussed your questions. We have no objection to the use of the word “computing” in the title of the MS in Quantum Computing. We recognize that there are a lot of different ways to approach teaching this topic. We would like to make sure that if we ever choose to teach a course that approaches quantum computing from the computing perspective, the Physics department would not object, and might consider allowing students in your MS program to take it as an option. We also would like to suggest that you could offer students in the program the option to take CSC 440 - Analysis of Algorithms, or CSC 544 -

Theory of Computation as part of their program.

We also recognize that if you offer the 5 year program you are suggesting, it would slightly impact our CSC 201/211 course. We don't anticipate that this will cause enrollment issues.

Take care,

Lisa

Dr. Lisa DiPippo, Chair
Department of Computer Science and Statistics
University of Rhode Island
Kingston, RI 02881
401-874-2701

Appendix 3: Course Map

Semester Map MS Degree Quantum Computing

F1	PHY51 0(3)/ 610(3)	PHY52 5(3)/ 670(3)	MTH51 3(4)	MTH45 1(3)	PHY45 1			7/10
S1	PHY62 6(3)	PHY58 0(3) PHY68 0(3)	PHY57 0(3)	PHY57 5(3)	PHY53 0(3)			12
summer	PHY57 7(4)							4
F2	PHY51 0(3)/ 610(3)	PHY52 5(3)/ 670(3)	PHY57 6(3)	MTH46 2(3)				6/9
S2	PHY59 1(3)	PHY58 0(3)/ PHY68 0(3)						6
TOTAL								38

Admission requirements: GRE and advanced test recommended; bachelor's degree with major in physics or closely related discipline. A grade of "B" or better in a rigorous quantum mechanics course is required.

Program requirements: PHY 510 or 610, 525, 530, 570, 575, 576, 577, 580, 591, 670, 680 MTH 513. The student will complete 30 credits, of which no more than six may be below the 500 level. This is a non-thesis program which requires that at least one course will require a substantial paper involving significant independent study, and the student must pass a final written and oral examination.

Green-lettered courses are recommended but not required, depending on student's background and interest.

PHY510 or 610 Mathematical Methods, **PHY570/670** Quantum Mechanics, **PHY525/625** Statistical Physics I and II, **PHY580/680** Condensed Matter, **PHY530** E&M, **PHY575** Introductory Quantum Computing, **PHY576** Advanced Quantum Computing, **PHY577** Internship in Quantum Computing, **PHY591**, Research Topic, **MTH451** Probability and Statistics, **MTH462** Functions of a Complex Variable, **MTH 513** Linear Algebra

MEMORANDUM

February 11, 2020

To: Leonard Kahn

From: Susan T. Brand, LOOC Interim Chair

This memo and the attached CLOAA-LOOC Plan Review Feedback Form constitute approval of your Program Assessment Plan for the proposed MS program in Quantum Computing. The new version of the plan (also attached) has the approval date on the first page and should replace any previous versions of this document. Please include this letter and the two attachments in your program proposal and **ensure that any language relating to learning outcomes, goals, etc. in your final proposal aligns with the final approval draft of the Assessment Plan.**

Good luck and speed with your full proposal!

Cc: E. Finan
J. Lawrence

Attachments

NEW PROGRAM ASSESSMENT PLAN REVIEW

Date SLOAA review:
12/2019
Date LOOC* review:
2-11-2020
STBrand

Academic Program/Degree: Quantum Computing, MS

College: College of Arts and Sciences

Date New Program Assessment Plan Submitted: December 2019

Faculty Member(s) Submitting Plan Proposal: Leonard Kahn

F E E D B A C K	Strengths:		
	SLOAA: <ul style="list-style-type: none"> The documentation for this graduate degree includes broad goals and well-defined learning outcomes aligned with the curriculum. Curriculum includes rigorous coursework and requires critical application of learning through opportunities such as an internship and independent research which also provide excellent opportunity for assessment of numerous learning outcomes toward the end of the curriculum to both examine student quality and the curriculum. External feedback from site supervisors ensures both students and the curriculum remain on track with industry needs and are prepared for job placement. Program takes advantage of existing qualifying exams from the PhD program by adapting them for use as Comprehensive exams in this MS; also optimizing the possibility of retaining students through the PhD program because they do not have to retake the specific exams if pass at the PhD level. The internship supervisors will assess students using a scoring tool linked to outcomes (knowledge and abilities). 		
	LOOC: <ul style="list-style-type: none"> Program is well aligned with the Strategic Plan and will fill a knowledge/skills void. 		
	Suggestions for improvement:		
	SLOAA: Program made improvements to Assessment Plan materials during consultations and after preliminary LOOC feedback. LOOC: (See SLOAA response)		
	Issue(s) of note:		
	SLOAA: <ul style="list-style-type: none"> The proposing faculty consulted with SLOAA throughout the process of refining the Plan. Although the program recognizes the undergraduate experience is reinforced in all Initial coursework, the early courses provide in-depth focus on specialized topics to introduce and prepare students to do quantum computing and understand how each topic relates to solving problems within this discipline, which begins with application of knowledge and skills in PHY 575. 		
	LOOC: <ul style="list-style-type: none"> Noted specific map and timeline discrepancies which were addressed by the program. Also, noted the extensive "introduction" of course material. Program provided explanation of the curriculum building knowledge and skills to PHY 575 where quantum computing applications begin. 		
Assessment Plan Designation:			
1 X		2 _____	3 _____
The Assessment Plan is ready for implementation.		The Assessment Plan can be implemented after minor revisions, as indicated, and does not require further review.	The Assessment Plan requires revisions, and should be submitted for further review after revisions, by date: _____

Program Information		Reviewer Ratings & Comments				
Information box complete		<input type="checkbox"/> Yes <input type="checkbox"/> Incomplete		<i>Suggestions:</i>		
Criteria		Efficacy of Plan Description & Content				Suggestions for improvement
		Less Developed	Developing	Well Developed	Not addressed	
PART I	1. Program goals					
	a. Broad statements of program learning goals	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	b. Limited in number (ideally 2-5)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
PART II	2. Learning outcomes/competencies					
	a. Linked to goals (numbered 1.1 etc.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	b. Each goal is represented by at least one outcome	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	c. Statements are observable/measurable	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	d. Directed at what students will know or be able to do	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	e. Reasonable number (ideally 1-3 per goal)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	3. Curriculum Map					
a. Program requirements are listed, developmentally when possible	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
b. Outcomes are linked to appropriate requirements	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Program identified critical assessment opportunities.	

		Reviewer Ratings & Comments				
Criteria		<i>Efficacy of Plan Description & Content</i>				<i>Suggestions for improvement</i>
		Less Developed	Developing	Well Developed	Not addressed	
PART III	4. Assessment Timeline (3-year plan)					
	a. Assessment Reporting Period 1 is thoroughly presented	==	==	==	==	
	b. Assessment Reporting Periods 2 and 3 are presented	==	==	==	==	
	c. All goals are represented by at least one outcome somewhere in the 3 reporting periods	==	==	==	==	
	d. Requirements are clearly stated and connected to outcomes (from Curriculum Map)	==	==	==	==	
	e. Evidence is stated for each designated outcome	==	==	==	==	
	f. Selection of evidence takes advantage of existing indicators	==	==	==	==	Both direct and indirect sources of evidence are used for a full picture of learning within courses and across the program curriculum throughout the student experience, and in the aggregate for the program-level perspective.
	g. Evidence is stated in enough detail to guide assessment activities	==	==	==	==	Several sources are identified
	h. Evidence is feasible for collection within the timeline	==	==	==	==	
	i. Methods for quantifying evidence are stated for each designated outcome	==	==	==	==	
	j. Methods are appropriate for evidence	==	==	==	==	All faculty are engaged in the process of scoring work and discussing results departmentally. Plan indicates planning for improvement is ongoing with full participation of faculty. Rubrics and scoring tools are used.

ACADEMIC PROGRAM ASSESSMENT PLAN

Date SLOAA review:
12/2019
Date LOOC* review:
2-11-2020
STBrand
*(LOOC Chair and review
subcommittee)

All new programs and certificates must have clearly articulated program goals (Section I) and student learning outcome statements linked to curriculum and course experiences/requirements (Section II). The Curriculum Map guides programs in to present the extent to which their student learning outcomes are aligned with courses and other program requirements intended to provide students with opportunities to develop and master the learning outcomes by graduation. Each program (not certificates) will also create an Assessment Timeline (Section III) indicating when and how learning outcomes assessment will take place. All undergraduate and graduate programs are encouraged to create a six-year (3 rounds) Assessment Plan to guide assessment reporting.

If you have questions or need assistance, please contact the Office of Student Learning, Outcome Assessment, and Accreditation (SLOAA) at assess@uri.edu.

Program Information	
Program:	Quantum Computing
Academic year plan submitted:	2020
Degree(s):	MS
Department Chair:	Leonard M. Kahn
Program Director:	Leonard M. Kahn
Accredited Program:	<input checked="" type="checkbox"/> No <input type="checkbox"/> Yes; specify year next accreditation report due: _____
Published learning outcomes (URL): <small>email to assess@uri.edu</small>	(Upon approval, the program will post student learning outcomes to the website).

Section I. Program Goals: Broad, general statements of what it means to be an effective program in terms of student learning outcomes; what the program wants students to know and be able to do upon completion of the program. Goals should relate to the mission of the department, college, and university in which the program resides. Success in achieving Goals is evaluated directly or indirectly by measuring specific outcomes (Section II) related to the goal.

Graduates of the program will:

Goal 1	Demonstrate an extensive knowledge base in quantum theory, mathematics, statistical physics, computer science with advanced skills in quantum computation.
Goal 2	Be trained as skilled researchers capable of integrating information from multiple disciplines to solve design problems in quantum computing.

*Add/delete lines as necessary

PROGRAM ASSESSMENT PLAN

Section II. Curriculum Mapping: Across the top of the matrix, list courses and other requirements for the program. Order the requirements from left to right in rough chronological/developmental sequence and add a standard description of your program requirements. Down the side, list program student learning outcomes associated with goals. Using the **Map Key** below, indicate the degree to which an outcome will be taught and assessed in relevant courses and by other program requirements. Use “*” to identify the best assessable moments in the curriculum.

Map Key I = Outcome Introduced in coursework R = Outcome Reinforced in coursework E = Outcome Emphasized for Mastery * = Courses included in program assessment Student Learning Outcomes (Competencies) by Goal: Statements of observable, measurable results of the educational experience, linked to program goals (Section I), that specify what a student is expected to know or be able to do throughout a program; these must be detailed and meaningful enough to guide decisions in program planning, improvement, pedagogy, and practice.		MTH513	PHY510/610	PHY525	PHY530	PHY570/PHY670 (sequence)	PHY580/680 (sequence)	PHY575	PHY577 Internship*	PHY576	PHY591 Independent Research*	Electives (up to 5 -depends on student experience)		
Goal 1	1.1 Formulate variational algorithms that operate in unique environments.	I	I		I	I	I	R	R	R	E	R		
	1.2 Implement a variety of error mitigation schemes.	I	I	I	I	I	I	R	R	R	R	R		
	1.3 Integrate principles of quantum and classical physics to create strategies that enhance problem solving unique to the discipline.	I	I	I	I	I	I	R	R	R	E	R		
	1.4 Apply quantum information theory to quantum communication networks, quantum sensing, randomness expansion, cryptography and teleportation.		I	I	I	I	I	R	R	R	E	R		
Goal 2	2.1 Formulate and design the method to address a research problem.							I	R	R	E	R		
	2.2 Investigate a research problem.	I	I	I	I	I	I	I	R	R	E	R		
	2.3 Present results of a research project to varied audiences in multiple formats.							I	R	R	E	R		

• Indicates best assessment opportunity.

PROGRAM ASSESSMENT PLAN

Section III. Assessment Timeline: Indicate when and how student learning will be assessed based on learning outcome statements and expectations. Refer to the curriculum map to propose an assessment timeline in which the program will plan to assess student learning outcomes. Specify a 6-year plan for assessment to represent **3 two-year reporting periods:**

- Assessment Reporting Period 1: the first academic year in which the program would plan to assess at least one outcome.
- Assessment Reporting Period 2: follows two years later, with plans defined for assessing another outcome(s).
- Assessment Reporting Period 3: follows two years later, with plans defined for assessing additional outcome(s).

All goal areas should be assessed by at least one outcome within the 6-year plan.

	Student Learning Outcome(s)	Course(s) and Other Program Requirements	Assessment Evidence of Student Learning	Assessment Method of Student Learning
Academic Years	<u>WHICH</u> outcome(s) will you examine in each period (use number(s) from curriculum map, e.g. 1.1)?	<u>WHERE</u> will you look for evidence of student learning (i.e., what course(s)/program requirements)? Designate for each outcome.	<u>WHAT</u> direct/indirect student work or other evidence of student learning will you examine in order to generate conclusions and recommendations? Designate for each requirement.	<u>HOW</u> will you look at the evidence; what means and process will you use to evaluate student learning (e.g., rubric, analysis of test scores, etc.)? Designate for each evidence source.
Assessment Reporting Period 1 Report Due May 2022*	1.1, 1.2	1) A. There are 4 Qualifying Exams; one occurs after PHY 575 B. 3 key courses (PHY 575, 576, 577) provide grades and scores from coursework which come from exams and assignments that include problem solving sets. 2) PHY 577 Internship	Direct evidence: 1) Qualifying Exam /Comprehensive Exam results in Quantum Computing (separate from course exams and assignments) 2) Assignments assessing application of specific knowledge and skills in advanced coursework 2.Application of knowledge in internship	1. Blind, anonymous, faculty wide separate scoring of qualifying exams; discussion and evaluation of learning results at department meeting to include correlation of courses grades with qualifying results; plans for improvement as needed. 2. External evaluation by internship advisor.

PROGRAM ASSESSMENT PLAN

Assessment Reporting Period 2 Report Due May 2024	1.3, 1.4	2) A. There are 4 Qualifying Exams which occur after PHY 525, 530, 570 B. 7 key courses: (PHY 525, 530, 570, 575, 576, 580, 680) provide grades and scores from coursework which come from exams and assignments that include problem solving sets	Direct evidence: 1) Qualifying Exam / Comprehensive Exam results in Statistical Physics, Electrodynamics, Quantum Mechanics (separate from course exams and assignments) 2) Assignments assessing application of specific knowledge and skills in advanced courses	1. Blind, anonymous, faculty wide separate scoring of qualifying exams using faculty designed rubric; discussion and evaluation of learning results at department meeting to include correlation of courses grades with qualifying exam results; plans for improvement as needed. 2) Assignment scores
Assessment Reporting Period 3 Report Due May 2026	2.1, 2.2, 2.3	PHY591 – independent research	Presentation of student research at department conference	1) All faculty evaluate presentations and score projects using rubrics with specific criteria for 3 areas: content, the written report, and the oral presentation. 2) Discussion and evaluation of results at departmental meeting; plans for improvement as needed.

* Initial reporting year is established by the program and depends on the anticipated timeframe for program implementation and student enrollment.



THE
UNIVERSITY
OF RHODE ISLAND



BUDGET AND FINANCIAL PLANNING

Adams House, 85 Upper College Road, Kingston, RI 02881 USA p: 401.874.2509 web.uri.edu/budget

DATE: January 21, 2020

TO: Nasser Zawia
Dean, Graduate School

FROM: Linda Barrett
Director, Budget and Financial Planning

SUBJECT: Proposal for an MS in Quantum Computing

As requested in an email from Leonard Kahn, Professor of Physics in the Colleges of Arts and Sciences, dated January 3, 2020, the Budget and Financial Planning Office has reviewed the original and revised submitted documents related to the proposal for an MS in Quantum Computing.

The Budget and Financial Planning Office, including communication with Enrollment Services, concurs that the request for an MS in Quantum Computing is expected to have a positive net revenue impact on the Fund 100 unrestricted budget as it has been presented.

Please let us know if you require any further information.

cc: Donald DeHayes
Anne Veeger
Jen Riley
Cheryl Hinkson
Joanne Lawrence
Margaret Benz
Leonard Kahn

Dean Libutti
Matthew Bodah
Nedra Reynolds
Colleen Robillard
John Humphrey
Brian Krueger

Office/BudgetImpactStatements/MSinquantumcomputing/BudgetImpactStatementLetter

ACADEMIC PROGRAM BUDGET FORM

Use this form for programs that can be pursued on a full-time basis, part-time basis, or through a combination of full-time and part-time attendPage.1 of 3

Choose one: ☒ Full-time ☐ Part-time ☐ Combination of full- and part-time

REVENUE ESTIMATES

	Year 1 2020		Year 2 2021		Year 3 2022		Year 4 2023	
Tuition: In-State	\$13,734		\$13,734		\$13,734		\$13,734	
Tuition: Out-State	\$26,512		\$26,512		\$26,512		\$26,512	
Tuition: Regional	\$20,602		\$20,602		\$20,602		\$20,602	
Mandatory fees per student	\$1,780		\$1,780		\$1,780		\$1,780	
FTE # of New Students: In-State	3		3		3		3	
FTE # of New Students: Out-State	2		5		6		6	
FTE # of new Students: Regional	1		1		1		1	
# of In-State FTE students transferring in from the institution's existing programs	0		0		0		0	
# of Out-State FTE students transferring in from the institution's existing programs	0		0		0		0	
TUITION AND FEES	Newly Generated Revenue	Revenue from existing programs	Newly Generated Revenue	Revenue from existing programs	Newly Generated Revenue	Revenue from existing programs	Newly Generated Revenue	Revenue from existing programs
First Year Students								
In-State tuition	\$41,202.00	\$0.00	\$41,202.00	\$0.00	\$41,202.00	\$0.00	\$41,202.00	\$0.00
Out-of-State tuition	\$53,024.00	\$0.00	\$132,560.00	\$0.00	\$159,072.00	\$0.00	\$159,072.00	\$0.00
Regional tuition	\$20,602.00	\$0.00	\$20,602.00	\$0.00				
Mandatory fees	\$10,680.00	\$0.00	\$14,240.00	\$0.00	\$16,020.00	\$0.00	\$16,020.00	\$0.00
Second Year Students								
In-State tuition			\$41,202.00	\$0.00	\$41,202.00	\$0.00	\$41,202.00	\$0.00
Out-of-State tuition			\$53,024.00	\$0.00	\$132,560.00	\$0.00	\$159,072.00	\$0.00
Regional tuition			\$20,602.00	\$0.00				
Mandatory fees			\$10,680.00	\$0.00	\$14,240.00	\$0.00	\$16,020.00	\$0.00
Third Year Students								
In-State tuition								
Out-of-State tuition								
Regional tuition								
Mandatory fees								
Fourth Year Students								
In-State tuition								
Out-of-State tuition								
Regional tuition								
Mandatory fees								
Total Tuition and Fees	\$125,508.00	\$0.00	\$334,112.00	\$0.00	\$404,296.00	\$0.00	\$432,588.00	\$0.00
GRANTS	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
CONTRACTS	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
OTHER (Specify)	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Total Grants, Contracts, Other	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
TOTAL	\$125,508.00	\$0.00	\$334,112.00	\$0.00	\$404,296.00	\$0.00	\$432,588.00	\$0.00

NOTE: All of the above figures are estimates based on projections made by the institution submitting the proposal.

ACADEMIC PROGRAM BUDGET FORM

Use this form for programs that can be pursued on a full-time basis, part-time basis, or through a combination of full-time and part-time attendPage.2 of 3

EXPENDITURE ESTIMATES

	Year 1 2020		Year 2 2021		Year 3 2022		Year 4 2023	
	Additional resources required for program	Expenditures from current resources	Additional resources required for program	Expenditures from current resources	Additional resources required for program	Expenditures from current resources	Additional resources required for program	Expenditures from current resources
PERSONNEL SERVICES								
Administrators			\$0.00		\$0.00		\$0.00	
Faculty	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Support Staff	\$0.00		\$0.00		\$0.00		\$0.00	
Others (Adjuncts)	\$15,000.00		\$15,000.00		\$15,000.00		\$15,000.00	
Fringe Benefits %	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Total Personnel	\$15,000.00	\$0.00	\$15,000.00	\$0.00	\$15,000.00	\$0.00	\$15,000.00	\$0.00
OPERATING EXPENSES								
Instructional Resources	\$0.00		\$0.00		\$0.00		\$0.00	
Other (specify)								
Total Operating Expenses	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
CAPITAL								
Facilities								
Equipment	\$5,000.00		\$5,000.00		\$5,000.00		\$5,000.00	
Other								
Total Capital	\$5,000.00	\$0.00	\$5,000.00	\$0.00	\$5,000.00	\$0.00	\$5,000.00	\$0.00
NET STUDENT ASSISTANCE								
Assistantships								
Fellowships								
Stipends/Scholarships								
Total Student Assistance	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
TOTAL EXPENDITURES	\$20,000.00	\$0.00	\$20,000.00	\$0.00	\$20,000.00	\$0.00	\$20,000.00	\$0.00

NOTE: All of the above figures are estimates based on projections made by the institution submitting the proposal.

ACADEMIC PROGRAM BUDGET FORM

Use this form for programs that can be pursued on a full-time basis, part-time basis, or through a combination of full-time and part-time attendance. **Page 3 of 3**

	Year 1 2018	Year 2 2019	Year 3 2020	Year 4 2021
BUDGET SUMMARY OF COMBINED EXISTING AND NEW PROGRAM				
Total Revenue	\$125,508.00	\$334,112.00	\$404,296.00	\$432,588.00
Total Expenses	\$20,000.00	\$20,000.00	\$20,000.00	\$20,000.00
Excess/Deficiency	\$105,508.00	\$314,112.00	\$384,296.00	\$412,588.00
BUDGET SUMMARY OF EXISTING PROGRAM ONLY				
Total Revenue	\$0.00	\$0.00	\$0.00	\$0.00
Total Expenses	\$0.00	\$0.00	\$0.00	\$0.00
Excess/Deficiency	\$0.00	\$0.00	\$0.00	\$0.00
BUDGET SUMMARY OF NEW PROGRAM ONLY				
Total of Newly Generated Revenue	\$125,508.00	\$334,112.00	\$404,296.00	\$432,588.00
Total of Additional Resources Required for Program	\$20,000.00	\$20,000.00	\$20,000.00	\$20,000.00
Excess/Deficiency	\$105,508.00	\$314,112.00	\$384,296.00	\$412,588.00

NOTE: All of the above figures are estimates based on projections made by the institution submitting the proposal.

Appendix 6: Dean's Letter of support
Len,

Thank you for the meeting this morning. I am excited about the Physics department's discussions regarding an applied master's in quantum technology/computing. As we discussed this morning, this development fits into the college strategic goals very well, and the Dean's office will support the program through funding for adjunct faculty as needed. As you know, the Dean's office also supports a hiring plan for the renewal of the faculty in the department.

I look forward to seeing the program come together and to supporting the department in this effort.

Best,
Jen

LIBRARY IMPACT STATEMENT (New Program Proposal)
LIBRARIAN'S ASSESSMENT

The Collection Management Officer will complete this form as requested, assessing library materials and collections as detailed below, returning. Subject selectors who receive requests for Library Impact Statements for new programs should forward those requests to the CMO.

Program: MS Quantum Computing

Department, College: Physics/A&S

Faculty Member: Leonard Kahn

Date returned to Faculty: 1/10/2020

Librarian Completing Assessment: Joanna M. Burkhardt

Collection Management Officer: Joanna M. Burkhardt

Assessment of:

- Suitability of existing library resources;
- New library resources required to support the program;
- Information skills education required by the students; and
- Funds needed for library materials and services.

Please include:

1. What library holdings already exist in relevant subject categories? How much money is now allocated in the program subject area?

The library holds current and historic materials in relevant subject categories. We have numerous subscriptions to journals in relevant subject categories. The current allocation for monographic purchases for Physics for 2019-20 is approximately \$2,000. The cost of journal subscriptions is generally not broken out by department or college.

2. Does URI have the essential journals as noted in the Faculty Questionnaire?

The library has the essential journals/databases as noted in the Faculty Questionnaire.

3. What new resources are required to support the program (including media, electronic, or other non-print materials)?

No new library resources are required to support this program.

4. What information mastery sessions will be required for the students?

No information mastery sessions are required for this program. However, individual instructors may make an appointment for a library information session at the beginning of any semester.

5. What is the approximate cost to acquire the materials necessary? Which of these will be continuing costs?

There are no new costs to the University Libraries associated with this program.