



**FLORIDA INTERNATIONAL UNIVERSITY
UNIVERSITY CURRICULUM COMMITTEE**
Proposal for a New Course

DO NOT TYPE IN THIS BOX

Bulletin # : 3

Academic Year : 2023-2024

1. **School/College** Engineering and Computing
Div./Dept. in Which Taught Knight Foundation School of Computing and Information Sciences

2. **COT** 5 3 **CIP Code (Leave this blank):** _____
 Alpha Prefix 1st Digit Last 3 Digits "C"-lec-lab "L"-Lab Cr. Hrs.

3. **Grading Method (select one):** Graded Pass/Fail

4a. **Course Title** Advanced Quantum Information and Probability

b. **Abbreviated course Title (for computer class schedules, transcripts)** Adv Quantum Info
LIMITED TO 25 Characters (including spaces)

5. **Statewide Course Numbering Subject Matter Area** Computation Theory (COT)

6. **Catalog Description/Major Topics** *(not to exceed 200 characters including spaces)*
College of Medicine and College of Law: Attach description not exceeding 1,000 characters including spaces.
Advanced topics in quantum information theory and probability; Quantum complexity classes; Quantum channel capacity; Quantum Fourier Transform; Quantum entanglement distillation.

7. **Attach detailed syllabus course outline and course justification on separate page(s).**

8. **Prerequisite(s):** Permission of the instructor

9. **Corequisite(s):** _____

10. **Objective(s) of Course:**
Describe axioms of quantum mechanics, superposition, entanglement, and the uncertainty principle
 Discuss quantum channel capacity
 Design quantum distillation mechanisms

11. **Does this course duplicate/overlap other courses at FIU?** No Yes
 If yes, please explain: _____

12. **What other closely related department(s) have been consulted about this course?**

13. **Is this course used for the assessment of a program or a certificate (if yes, then send a notification to assessment@fiu.edu)?** No Yes

PROPOSAL REQUESTED BY:

Faculty Contact	<u>Farhad Shirani Chaharsooghi</u>	<u><i>Farhad Shirani</i></u>	<u>10</u> / <u>12</u> / <u>2023</u>
	(Type name)	(Signature)	
	<u>fshirani@fiu.edu</u>	<u>305-348-8036</u>	
	(Email address)	(Phone number)	
Chairperson (Dept./Div.)	<u>Jason Liu</u>	<u><i>[Signature]</i></u>	<u>11</u> / <u>1</u> / <u>2023</u>
	(Type name)	(Signature)	
Chairperson (Curr. Comm.)	<u>Alexander Afanasyev</u>	<u><i>[Signature]</i></u>	<u>11</u> / <u>15</u> / <u>2023</u>
	(Type name)	(Signature)	
College/School Dean	<u>Mark Weiss, Assoc Dean</u>	<u><i>Mark Weiss</i></u>	<u>11</u> / <u>17</u> / <u>2023</u>
	(Type name)	(Signature)	

Submit one original form. Attach one copy of the course justification and course syllabus, course description, objectives, major topics and textbooks.

Subject: RE: Introducing Two New Courses on Quantum Information and Probability

From: Deidra Hodges <dhodges@fiu.edu>

Date: 10/31/2023, 2:19 PM

To: Farhad Shirani Chaharsooghi <fshirani@fiu.edu>

CC: Jason Liu <liux@fiu.edu>, Nagarajan Prabakar <prabakar@cis.fiu.edu>, sadjadiATcs <sadjadi@cs.fiu.edu>, Ou Bai <obai@fiu.edu>, Nezhil Pala <npala@fiu.edu>, Aleksandr Krasnok <akrasnok@fiu.edu>, Armando Barreto <barretoa@fiu.edu>, Vladimir Pozdin <vpozdin@fiu.edu>

Hi Dr. Chaharsooghi,

Thank you for sharing your proposals. I have reviewed them and am glad to see you had the review of Dr. Krasnok. We support your proposals and we look forward to our students being able to take these courses. We look forward to collaborative efforts!

Thanks again,

Deidra

Deidra R. Hodges, Ph.D.

ECE Department Chair, Associate Professor

Department of Electrical and Computer Engineering

College of Engineering and Computing, EC 3984

Florida International University

10555 West Flagler Street

Miami, FL 33174

P: (305) 348-5091 | Email: dhodges@fiu.edu



From: Farhad Shirani Chaharsooghi <fshirani@fiu.edu>

Sent: Monday, October 30, 2023 11:59 AM

To: Deidra Hodges <dhodges@fiu.edu>

Cc: Jason Liu <liux@fiu.edu>; Nagarajan Prabakar <prabakar@cis.fiu.edu>; sadjadiATcs <sadjadi@cs.fiu.edu>

Subject: Introducing Two New Courses on Quantum Information and Probability

Dear Professor Hodges,

I hope that this email finds you well.

I am writing this email about two courses on 'Quantum Information and Probability' which I am planning to introduce, one in the undergraduate level and one in the graduate level.

I have attached the course proposals and other relevant documents to this email.

These course proposals have completed the departmental review processes in the corresponding committees at KFSICS. Furthermore, I have sought feedback, and received valuable positive input, from Professor Alex Krasnok at the ECE Department, along with several other faculty members in the field, regarding the course composition and contents.

I would be grateful for any additional comments and feedback from the faculty at the ECE department on these course proposals. I am very excited about the prospect of introducing these courses in the coming

academic year, and hope that these along with other quantum courses offered at our university will facilitate student training, and formation of strong research groups in various quantum research areas, which in turn would augment ongoing collaborative efforts on attracting funding and producing quality research in this area.

Thank you for your time and consideration.

Best regards,
Farhad Shirani

Farhad Shirani
Assistant Professor
Knight Foundation School of Computing and Information Sciences
Florida International University
<https://pi-colab.github.io/>
fshirani@fiu.edu

Course 5XXX Advanced Quantum Information and Probability

New Course Justification

Providing education and training in quantum information to computer science graduates can offer them a bright career path in an emerging field of considerable national interest. This field has gained significant attention in recent times, and there is a vibrant industry growing around it.

Topics covered include: Postulates of quantum mechanics; quantum circuits and gates; entanglement, teleportation and Bell's inequality; quantum complexity classes; introduction to quantum error-correcting codes; quantum communications, quantum Fourier transform, quantum key generation and entanglement distillation.

Knight Foundation School of Computing and Information Sciences

Course Title: Advanced Quantum Information and Probability **Date:** 18/03/2023

Course Number: COT 5XXX

Number of Credits: 3

Subject Area: Foundations	Subject Area Coordinator: Hadi Amini email: amini@cs.fiu.edu
Catalog Description: Advanced topics in quantum information theory and probability; Quantum complexity classes; Quantum channel capacity; Quantum Fourier Transform; Quantum entanglement distillation.	
Textbook: Quantum Computation and Quantum Information: 10th Anniversary Edition Authors: Michael A. Nielsen, Isaac L. Chuang ISBN-10: 9781107002173	
References: Printed lecture notes will be provided.	
Prerequisites: Permission of the instructor	
Corequisites: None	

Type: Elective

Prerequisites Topics:

- Boolean algebra
- Probability Theory

Course Outcomes:

1. State the axioms of quantum mechanics [Remember]
2. Explain quantum superposition, entanglement, teleportation, and the uncertainty principle [Understanding]
3. Evaluate algorithms in sense of classical and quantum complexity classes [Evaluating]
4. Analyze classical-quantum and quantum-quantum channels [Analyzing]
5. Design CSS encoding and decoding mechanisms [Creating]
6. Understand quantum Fourier transforms and applications in quantum key generation [Understanding]

Knight Foundation School of Computing and Information Sciences
COT 5XXX
Advanced Quantum Information and Probability

Outline

Topic	No. of Lecture Hours	Outcome
<ul style="list-style-type: none"> • Review of Probability and Linear Algebra <ul style="list-style-type: none"> ○ Matrices, matrix operations, and traces ○ Random Variables ○ Joint Distributions and Conditional Distributions ○ Tensor Products 	3	1
<ul style="list-style-type: none"> • Axioms of Quantum Mechanics <ul style="list-style-type: none"> ○ Quantum States and State Spaces ○ State Evolution ○ Projective and General Measurements ○ Composite State Spaces 	3	2
<ul style="list-style-type: none"> • Quantum Protocols and Complexity Classes <ul style="list-style-type: none"> ○ Classical vs Quantum Complexity Classes ○ Quantum Security and Introduction to Post-Quantum Cryptography 	5	3,6
<ul style="list-style-type: none"> • Quantum Information and Capacity <ul style="list-style-type: none"> ○ Uncertainty Principle and Quantum Ensemble ○ Purification ○ Quantum Conditional Probability ○ Von Neuman Entropy ○ Quantum Channel Capacity 	3	4
<ul style="list-style-type: none"> • Quantum Error Correction <ul style="list-style-type: none"> ○ Bit-flip channel and Phase flip-channel ○ CSS Code ○ Decoding CSS Code 	6	4,5
<ul style="list-style-type: none"> • Quantum Fourier Transform and Applications <ul style="list-style-type: none"> ○ Quantum Fourier Transform ○ Shor's Quantum Algorithm for Finding Order ○ Classical Post-Processing 	5	5
<ul style="list-style-type: none"> • Quantum Entanglement Distillation and Key Generation <ul style="list-style-type: none"> ○ Classical Correlation Distillation ○ Entanglement Distillation ○ Applications in Key Generation 	5	6

Knight Foundation School of Computing and Information Sciences
COT 5XXX
Advanced Quantum Information and Probability

Course Outcomes Emphasized in Laboratory Projects / Assignments

	Outcome	Number of Weeks
1	Linear Algebra and Probability Theory Review Exercises Outcomes: 1	1.5
2	Axioms of Quantum Mechanics Exercises Outcomes: 2	3
3	Quantum Algorithms and Complexity Exercises Outcomes: 3	3
4	Quantum Capacity and Coding Exercises Outcomes: 4,5	3.5
5	Quantum Fourier Transform Exercises Outcomes: 6	4