DO NOT TYPE IN THIS BOX

Bulletin # : 3

Academic Year : 2022-23

FLORIDA INTERNATIONAL UNIVERSITY
UNIVERSITY CURRICULUM COMMITTEE
Proposal for a New Course

1. **School/College** College of Engineering and Computing

   Div./Dept. in Which Taught Knight Foundation School of Computing and Information Sciences

2. | COT | 5 | | | 3 |
   |---|---|---|---|---|
   | Alpha Prefix | 1st Digit | Last 3 Digits | "C"-lec-lab "L"-Lab | Cr. Hrs. |

   CIP Code *(Leave this blank):*

   COT 5600

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

4a. **Course Title** Quantum Algorithms

   b. **Abbreviated course Title** *(for computer class schedules, transcripts)* Quantum Algorithms

   LIMITED TO 25 Characters *(including spaces)*

5. **Statewide Course Numbering Subject Matter Area** Computing Theory

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.

   Introduction to quantum theory and a survey of standard and advanced quantum algorithms; implementation of algorithms on a simulated or real quantum system.

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

8. **Prerequisite(s):** COT 5407 or COT 6405 or permission by the instructor

9. **Corequisite(s):**

10. **Objective(s) of Course:**

    Describe fundamental concepts of quantum computing
    Discuss quantum computer architecture
    Analyze standard and advanced quantum algorithms
    Design and evaluate implementation of quantum algorithms

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?**

    Department of Electrical and Computer Engineering

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 Nagarajan Prabkar _____ / _____ / 20 22
(Type name) (Signature)

prabakar@fiu.edu 305-348-2033
(Email address) (Phone number)

Chairperson (Dept./Div.) Jason Liu _____ / _____ / 20 22
(Type name) (Signature)

Chairperson (Curr. Comm.) _____ / _____ / 20 22
(Type name) (Signature)

College/School Dean John Volakis _____ / _____ / 20 22
(Type name) (Signature)

Submit one original form. Attach one copy of the course justification and a draft of the course syllabus for this New Course Proposal. The syllabus should include the course description, objectives, learning outcomes, major topics, and textbooks.

FIU | Engineering & Computing

FLORIDA INTERNATIONAL UNIVERSITY

To: Mary Cossio
Faculty Senate

From: Dean or Assoc. Dean and College Curriculum Cmte. Chair

Subject: Memo in Lieu of Curriculum Chair and Dean Signatures for Bulletin #3

Date: November 24, 2022

As instructed by the Faculty Senate, this memo will serve as approval of the attached proposals for Bulletin #3 by our Curriculum Committee Chair, Alexander Afanasyev, and the Dean for College of Engineering and Computing (John L. Volakis), in lieu of physical signatures. The proposals in this Bulletin were approved by our Curriculum Committee on November 23, 2022.

In addition to the above, memos in lieu of signatures have also been included by departments unable to obtain physical signatures for their faculty contact and/or department chair.

FIU Engineering & Computing
FLORIDA INTERNATIONAL UNIVERSITY

To: Mary Cossio
Faculty Senate

From: Faculty Contact and KFSCIS Interim Director

Subject: Memo in Lieu of Curriculum Chair and Dean Signatures for Bulletin #3

Date: November 24, 2022

As instructed by the Faculty Senate, this memo will serve as approval of the attached proposals from KFSCIS for Bulletin #3 by faculty contact (Nagarajan Prabkar) and KFSCIS Interim Director (Jason Liu), in lieu of physical signatures. The proposals in this Bulletin were approved by our Curriculum Committee on November 23, 2022.

COT 5XXX Quantum Algorithms

New Course Justification

Quantum computing is an emerging technology of national importance. Educating and training Computer Science graduates with quantum expertise will increase their career prospects and meet society's technological needs.

This advanced elective course requires algorithmic analysis as a prerequisite. Graduate students with this prerequisite will gain experience in the design of quantum algorithms. Additionally, they can extend their graduate research in the quantum area.

Knight Foundation School of Computing and Information Sciences

Course Title: Quantum Algorithms **Date:** 11/7/2022

Course Number: COT 5XXX

Number of Credits: 3

Catalog Description: Introduction to quantum theory and a survey of standard and advanced quantum algorithms; implementation of algorithms on a simulated or real quantum system.
Textbook: "Quantum Computation and Quantum Information" (10th Ed) Nielsen and Chuang ISBN-13: 978-1-107-00217-3
References: Online reference materials
Prerequisites: COT 5407 or COT 6405
Corequisites: None

Type: Elective

Prerequisites Topics:

- Linear algebra
- Data structures
- Algorithm analysis

Course Outcomes:

1. Describe fundamental concepts of quantum computing [Understanding]
2. Discuss quantum computer architecture [Understanding]
3. Analyze standard quantum algorithms [Analyzing]
4. Summarize advanced quantum algorithms [Understanding]
5. Design and evaluate implementation of quantum algorithms [Creating]

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

Outline

Topic	No. of Lecture Hours	Outcome
• Overview of Quantum Computing o Basic quantum mechanics o Classical vs Quantum systems o Quantum computer architectures o Complex Numbers o Linear Algebra – vector and matrix operations	4	1
• Quantum States and Quantum Gates o Dirac notation, Bloch sphere, Hilbert space o Quantum superposition o Single qubit gates o Multiple qubit gates o Quantum entanglement, Bell state	4	2
• Standard Quantum Algorithms o Deutsch-Jozsa Algorithm o Bernstein-Vazirani Algorithm o Simon's Algorithm o Grover's Algorithm o Quantum Fourier Transform o Shor's Algorithm	12	3
• Advanced Quantum Algorithms o Quantum Counting o Quantum Walk Search Algorithm o Quantum Teleportation o Quantum error correcting code o Quantum Key Distribution	6	4, 5
• Challenges in Quantum Technology o Quantum measurement o Cloning theorem o Scalability in real quantum systems	4	

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

Course Outcomes Emphasized in Laboratory Projects / Assignments

	Outcome	Number of Weeks
1	Quantum mechanics & linear algebra exercises Outcomes: 1	2
2	Quantum circuit design Outcomes: 2	2
3	Implementation of a simple quantum algorithms Outcomes: 3	3
4	Implementation of an advanced quantum algorithm Outcomes: 4, 5	5

FW: New Quantum Computing courses

Trevor Cickovski <tcickovs@cs.fiu.edu> Mon, Nov 14, 2022 at 6:29 PM
To: Nagarajan Prabakar <prabakar@fiu.edu>, Trevor Cickovski <tcickovs@fiu.edu>, Jason Liu <liux@fiu.edu>
Cc: Masoud Sadjadi <sadjadi@fiu.edu>

Ok, sounds good -- looks like you envision just being in-person so there should not be any issue. I think we can move forward and create the course.

-Trevor

On 11/14/2022 2:06 PM, Nagarajan Prabakar wrote:

> HI Trevor,
>
> I will be teaching COP-4XXX in-person mode as an experimental course in Spring'23.
>
> Also, in future I plan to teach both courses in-person (Fall – COP5XXX and Spring – COP4XXX).
>
> Thanks
>
> --Prabu
>
> **From:** Trevor Cickovski <tcickovs@cs.fiu.edu>
> **Sent:** Monday, November 14, 2022 8:07 AM
> **To:** Nagarajan Prabakar <prabakar@fiu.edu>; Trevor Cickovski <tcickovs@fiu.edu>; Jason Liu <liux@fiu.edu>
> **Cc:** Masoud Sadjadi <sadjadi@fiu.edu>
> **Subject:** Re: FW: New Quantum Computing courses
>
> Prabu:
>
> It looks like ECE generally has no objection to your courses, they just would like them to be offered in-person.
>
> I did not see anywhere in your attachments where you insisted the courses be online? Would you have any issue with teaching them in-person? If not, it seems we are okay.
>
> Best,
>
> Trevor
>
> On 11/12/2022 7:15 PM, Nagarajan Prabakar wrote:
>
> > Hi Trevor,
> >
> > I have forwarded below the email trail with ECE about our two new quantum courses.
> >
> > For the details of our quantum courses, please review the seven attachments from my earlier email dated 11/8/22@11:50pm.
> >
> > The clear distinction between ECE and our courses are
> >
> > 1. Course focus (ECE: Quantum hardware; KFSCIS: quantum theory and algorithms)
> > 2. Prereq (both academic units have different prereq)
> >
> > Let me know what course of action to follow.
> >
> > Thanks
> >
> > --Prabu
> >
> > **From:** Aleksandr Krasnok <akrasnok@fiu.edu>
> > **Sent:** Thursday, November 10, 2022 2:05 PM

To: Nezih Pala <npala@fiu.edu>; Nagarajan Prabakar <prabakar@fiu.edu>
Subject: RE: New Quantum Computing courses

Dear Nezih,

This sounds very interesting! The only concern is that I prefer teaching in person. Let's discuss this over Zoom or in person?

Dear Prabakar, please let us know if you see how we can combine our effort in teaching quantum!

Best regards,

Alex Krasnok, Ph.D.,

Assistant Professor

Electrical & Computer Engineering

Florida International University

Room#: EC 2777

10555 W Flagler Street

Miami, FL 33174-1630

Phone: (737)781-1203

Web: https://www.krasnok.com/

GS: Alex Krasnok

From: Nezih Pala <npala@fiu.edu>
Sent: Thursday, November 10, 2022 9:12 AM
To: Aleksandr Krasnok <akrasnok@fiu.edu>; Nagarajan Prabakar <prabakar@fiu.edu>
Subject: RE: New Quantum Computing courses

Hello,

We proposed 2 quantum courses in ECE:

EEE 4423 Introduction to Quantum Computers

EEE 6429 Advanced Quantum Computers

They have been approved with their permanent course numbers.

Indeed, they are intended to focus on the hardware principles and algorithms.

I offered EEE 6429 in Spring 2022 for the first time as a fully online course.

Alex,

You are welcome to teach it. In fact, we can jointly develop both courses and teach in rotation.

Best,

Nezih Pala, PhD
Professor
Eminent Scholar Chaired Professor

Electrical & Computer Engineering
Florida International University
Room#: EC 3142
10555 W Flagler Street
Miami, FL 33174-1630
Phone: (305) 348 3016
https://insyst.fiu.edu/

From: Aleksandr Krasnok <akrasnok@fiu.edu>
Sent: Wednesday, November 9, 2022 2:44 PM
To: Nagarajan Prabakar <prabakar@fiu.edu>; Nezih Pala <npala@fiu.edu>
Subject: RE: New Quantum Computing courses

Dear Prabakar,

As I can see, the quantum courses at EE are more hardware oriented. In contrast, the COT courses are software with a focus on quantum algorithms.

Potentially, we can take advantage of both courses if students take them all together or one right after another.

BTW, I had never heard of this graduate course, *EEE 6429 - Advanced Quantum Computers*, to be teched online by Prof. Pala. I was going to teach another (special topics) course on quantum materials and technologies that I taught last spring semester.

Dear @Nezih Pala, could you please tell us more about this course? Is it given a permanent number? Have you already taught this course? Is it all online, as the Course Catalog says, or do you plan to teach it in person? As I can see, we have a good overlap between your course and mine.

Best regards,

Alex Krasnok, Ph.D.,

Assistant Professor

Electrical & Computer Engineering

Florida International University

Room#: EC 2777

10555 W Flagler Street

Miami, FL 33174-1630

Phone: (737)781-1203

Web: https://www.krasnok.com/

GS: Alex Krasnok

From: Nagarajan Prabakar <prabakar@fiu.edu>
Sent: Wednesday, November 9, 2022 2:22 PM
To: Aleksandr Krasnok <akrasnok@fiu.edu>
Subject: New Quantum Computing courses

Dear Alex,

I understand that ECE offers the following two courses on quantum computers:

EEE 4423 Introduction to Quantum Computers

Description: This course provides the foundations of quantum computers and quantum information systems with an emphasis on physical implementations.

Prerequisites: EEL 3120(Introduction to Linear Systems in Engineering), EEL 3135(Signals and Systems).

EEE 6429 Advanced Quantum Computers

Description: This course provides advanced principles of quantum computers and quantum information systems with in-depth analysis and state of the art physical implementations.

For computing majors, courses with quantum theory and quantum algorithm will be essential. I have prepared the following two new courses and attached their syllabi:

COT 4XXX Fundamentals of Quantum Computing

COT 5XXX Quantum Algorithms

Would you review these two course syllabi and let me know if there is any significant overlap between these new courses and ECE Quantum Computers courses.

Regards

--Prabakar

--

****

Trevor Cickovski

Associate Teaching Professor of Computer Science

Interim Associate Director, Knight Foundation School of Computing and Information Sciences (KF-SCIS)

CASE280D

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"You learn more from missing a tough target than hitting an easy one."

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