



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

<b>DO NOT TYPE IN THIS BOX</b>
Bulletin # : <u>6</u>
Academic Year : <u>2021-22</u>

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

2. **COT** 4 XXX 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** Optimization Methods for Computing: Theory and Applications

b. **Abbreviated course Title (for computer class schedules, transcripts)** Opt. Com. Thr. & Appl.  
LIMITED TO 25 Characters (including spaces)

5. **Statewide Course Numbering Subject Matter Area** COT (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.*

Optimization for CS students, including introduction to optimization algorithms, applications in CS, efficient computing, and real-world problems. Basic calculus and programming skill are needed.

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

8. **Prerequisite(s):** MAC 2311 Calculus I or equivalent (instructor's permission is acceptable)

9. **Corequisite(s):** MAS 3105 or COT3510 or equivalent (instructor's permission is acceptable)

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

Provide students with a solid and comprehensive understanding of optimization algorithms, focusing on their pivotal role in computing/decision making, as well as real-world applications.

11. **Does this course duplicate/overlap other courses at FIU?**  No  Yes

**If yes, please explain:** The course had some overlap with some mechanical engineering courses. We had discussed that with them for the approval of graduate version of the course proposal.

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

Mechanical 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** Mohammadhadi Amini  1 / 20 / 2022  
 (Type name) (Signature)  
moamini@fiu.edu 412-626-4064  
 (Email address) (Phone number)

**Chairperson (Dept./Div.)** Jason Liu See attached memo \_\_\_\_\_ / \_\_\_\_\_ / 20  
 (Type name) (Signature)

**Chairperson (Curr. Comm.)** Elias Alwan  3 / 23 / 20  
 (Type name) (Signature)

**College/School Dean** John Volakis See attached memo \_\_\_\_\_ / \_\_\_\_\_ / 20  
 (Type name) (Signature)

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

## MEMORANDUM

To: Mary Cossio  
Faculty Senate

From: Faculty Contact and KFSCIS Chair

Subject: **Memo in Lieu of Faculty Contact and School's Director Signatures for Bulletin #6**

Date: March 16, 2022

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As instructed by the Faculty Senate, this memo will serve as approval of the attached proposals for Bulletin #6 by our Faculty Contact (Mohammadhadi Amini) and KFSCIS Interim Director (Jason Liu) in lieu of physical signatures. The proposals in this Bulletin were approved by our Curriculum Committee on (03/16/2022).

## MEMORANDUM

To: Mary Cossio  
Faculty Senate

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

Subject: **Memo in Lieu of Curriculum Chair and Dean Signatures for Bulletin #6**

Date: March 16, 2022

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As instructed by the Faculty Senate, this memo will serve as approval of the attached proposals for Bulletin #6 by our Curriculum Committee Chair (Elias Alwan), 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 (03/16/2022).

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.

# **Optimization Methods for Computing: Theory and Applications**

Instructor: Mohammadhadi Amini

## **Course Justification**

Ever-increasing integration of sensing and measurement technologies in the Internet-of-Things (IoT) environment enabled real-time computing for monitoring and control of different networks, including communication networks, power grids, and transportation networks. Wireless sensors networks, smart meters, and intelligent road side units are examples of emerging technologies that help sensing the system states and leverage this data to optimize the operation of networks. This further leads to a crucial need to develop theoretical algorithms to analyze enormous amount of collected data in a computationally-efficient fashion. It is crucial for computer science (CS) students, specifically those who are interested in real-time computing, decision making, and learning methods, as well as data analytics, to understand the theoretical aspects of the tools that they deploy in research, fundamental notions of optimization, and applying optimization tools and algorithms to computing problems.

There are courses on data science and machine learning at FIU, including Principles of Data Mining, Introduction to Data Science, Introduction to Machine Learning, and Capstone in Data Science classes. Aforementioned courses mainly investigate the data science and machine learning algorithms and tools. It is imperative to develop a course that provides the introduction to optimization algorithms from computing perspective, and prepare students to understand the theoretical foundations of computing and decision making tools, including data science and machine learning tools from an optimization perspective. This undergraduate-level course (Optimization Methods for Computing: Theory and Applications) will thoroughly describe optimization theory as a foundation for several areas in CS, including but not limited to learning and data science, as well as engineering, including but not limited to system engineering, electrical engineering, and civil engineering. Students will be equipped with strong theoretical tools that can be applied to a wide spectrum of applications. This course will also strengthen their vision and understanding of the complexity behind these tools in terms of various optimization techniques for efficient computing.

There are courses on optimization from mathematical perspective at Math and Statistics departments at FIU, including Numerical Optimization, and Optimization and Linear Algebra. These courses provide solid theoretical foundations for optimization and require some prerequisites which are not mainly taken by CS students. The first part of proposed course covers the required concepts for numerical optimization, including an overview of linear algebra. Although the mentioned two courses focus on the theoretical concepts, proofs, and fundamental linear algebra, the proposed course focuses on deploying optimization in computer science, especially this course focuses on efficient computing, learning, and data science. There are two additional components in the proposed course: 1) decomposition techniques for efficient computing and large-scale optimization, 2) introducing applications in data science, machine learning, and real-world problems. The proposed course is self-explanatory and provides essential required background for CS students before introducing each optimization algorithm. Further, there is a course at Mechanical Engineering on Optimization Algorithms. The optimization course offered by Mechanical Engineering department is mainly focused on commercial tools for solving optimization problems. In the proposed course, however, the main emphasize is on optimization algorithms, decomposition techniques to solve them efficiently, and their application in machine learning and data

science. The only overlap in the proposed syllabus is providing a quick overview of related Python libraries/ MATLAB functions. Hence, proposed course will not spend time on detailed introduction of commercial optimization tools. The focus is more the algorithm side and computer science applications. Further, proposed course will not teach evolutionary and nature-inspired algorithms.

**Overview: This course mainly focuses on optimization problems and efficient techniques to solve them. The course is designed to be self-explanatory, i.e., students from various backgrounds (computer science, civil engineering, electrical and computer engineering, statistics, construction engineering, and other areas that deploy optimization in their research) are eligible to take this course. This a project0based course. Students will propose and work on a semester-long course project which is aligned with their research interests and experience. For Further details, please email moamini@fiu.edu**

**Content:** It is crucial for computer science and engineering students, specifically those who are interested in real-time computing, optimization, decision making, and learning methods, as well as data analytics, to understand the theoretical aspects of the tools that they deploy in research, basic notions of optimization, and applying optimization tools and algorithms to computing problems. In order to bridge the gap between optimization theory and its applications, this course provides comprehensive understanding of optimization and its applications. It covers a wide spectrum of problems from the foundations of optimization, different classes of problems (constrained/unconstrained, linear/nonlinear), solution methods and algorithms, and duality theory, towards the role of optimization in Computer Science and Engineering areas.

In order to expose student to real-world problems, practical use-cases from different application domains will be introduced during the semester. Students will be engaged in the learning process by solving hands-on problems during the class. This new course will provide CS students with a thorough understanding of theory behind several tools. Several senior positions in industry as well as national labs require such solid background as a complement to numerous data science tools. As the required preliminaries and mathematical concepts are covered in the class, it also can benefit non-CS students in the College of Engineering and Computing who are interested in applying optimization methods to their research for several computing and engineering applications.

## School of Computing and Information Science

**Course Title:** Optimization Methods for Computing: Theory and Applications **Date:** 09/03/2019

**Course Number:** COT 4XXX

**Number of Credits:** 3

<b>Subject Area:</b> Data Science	<b>Subject Area Coordinator:</b> <b>email:</b>
<b>Catalog Description:</b> Optimization for CS undergraduate students, including algorithms, applications to widely used methods including efficient computing, machine learning and data science, and real-world problems. Basic calculus and programming skills are needed.	
<b>Textbook:</b> Boyd, Stephen, and Lieven Vandenberghe. <i>Convex optimization</i> . Cambridge university press, 2004.	
<b>References:</b> None	
<b>Prerequisite Courses:</b> MAC 2311 Calculus I or equivalent (instructor's permission is acceptable)	
<b>Corequisite Courses:</b> MAS 3105 Linear Algebra or COT 3510 Applied Linear Structures for Computing or equivalent (instructor's permission is acceptable)	

**Type:** Elective

**Prerequisite Topics:**

- Calculus, Basic Programming (e.g., Python)

**Course Outcomes:**

Students who successfully complete this course will be able to:

1. Explain the general concepts of optimization theory, linear/nonlinear optimization, convex/nonconvex problems;
2. Formulate an optimization problem from scratch, and utilize the most efficient algorithm to solve the formulated problem;
3. Describe decomposition techniques, their step by step implementation, and advantages for large-scale computational problems;
4. Identify computing and decision making problems, e.g., data analytics and machine learning, and the theoretical optimization problems behind each notion
5. Explain and discuss emerging real-world applications of optimization for learning and data science, e.g., energy demand forecasting, traffic flow optimization, and community analysis in social networks.

**Outline:**

Topic	Number of Lecture Hours (Total: 37.5 hours = 15 weeks * 2 lectures/week * 1.25 hrs/lecture)	Outcome
<b>Introduction to Optimization</b> <ul style="list-style-type: none"><li>• What are the main roles of optimization in computing?</li><li>• How to formulate an optimization based on a real-world computing problem?</li><li>• What are the applications of optimization in learning and data sciences?</li></ul>	5	1,2
<b>Preliminaries</b> <ul style="list-style-type: none"><li>• Linear algebra and matrix calculus preliminaries</li><li>• Eigen value decomposition, singular value decomposition, matrix inversion</li><li>• Overview of related Python libraries/ MATLAB functions</li></ul>	2.5	1,2,4
<b>Centralized algorithm for general optimization problems</b> <ul style="list-style-type: none"><li>• How to formulate and solve unconstrained optimization</li><li>• How to formulate and solve constrained optimization</li><li>• Karush–Kuhn–Tucker (first order necessary) conditions</li><li>• Example: Optimal energy management in data centers</li></ul>	3.75	1,2
<b>Convexity</b> <ul style="list-style-type: none"><li>• What is the definition of convex optimization?</li><li>• How can we solve convex optimization problems?</li><li>• Duality theorem</li></ul>	2.5	1,2,3
<b>Decomposition techniques for nonlinear optimization</b> <ul style="list-style-type: none"><li>• Lagrangian decomposition</li><li>• Augmented Lagrangian decomposition</li></ul>	10	1,3,4
<b>Decomposition techniques for linear optimization</b> <ul style="list-style-type: none"><li>• Dantzig-Wolfe decomposition</li><li>• Benders decomposition for linear problems</li></ul>	6.25	1,3,4,5
<b>Optimization for decision making and computing</b> <ul style="list-style-type: none"><li>• Understanding the role of optimization theory in computer science tools and problems</li><li>• How can we formulate a learning problem as an optimization problem? How to use the skills from this course to solve the formulated problem?</li><li>•</li></ul>	6.25	4,5
<b>Real-world examples of optimization</b>	1.25	4,5

**From:** Trevor Cickovski <movingpictures83@gmail.com>  
**Subject:** Fwd: Please confirm you approve  
**Date:** March 17, 2022 at 12:51 PM  
**To:** Alex Afanasyev <aa@cs.fiu.edu>  
**Cc:** Hadi Amini <amini@cs.fiu.edu>

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Hi Alex:  
See Arvind Agarwal's response on Hadi's course.

Good to go?  
-Trevor

----- Forwarded message -----

From: **Arvind Agarwal** <[agarwala@fiu.edu](mailto:agarwala@fiu.edu)>  
Date: Thu, Mar 17, 2022 at 6:54 AM  
Subject: Re: Please confirm you approve  
To: Trevor Cickovski <[movingpictures83@gmail.com](mailto:movingpictures83@gmail.com)>

okay, proceed.

**Arvind Agarwal, Ph.D., FASM, FACerS, FAAAS**  
*Chair and Distinguished University Professor*  
[Mechanical and Materials Engineering](#)  
Director, [Advanced Materials Engineering Research Institute \(AMERI\)](#)  
College of Engineering and Computing  
Florida International University  
10555 West Flagler Street, EC 3474  
Miami, FL 33174  
P: (305) 348-1701 | F: (305) 348-1932 | E: [agarwala@fiu.edu](mailto:agarwala@fiu.edu)  
<http://pfl.fiu.edu>  
<http://ameri.fiu.edu>

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**From:** Trevor Cickovski <[movingpictures83@gmail.com](mailto:movingpictures83@gmail.com)>  
**Sent:** Wednesday, March 16, 2022 5:20 PM  
**To:** Arvind Agarwal <[agarwala@fiu.edu](mailto:agarwala@fiu.edu)>  
**Subject:** Re: Please confirm you approve

Hi Arvind:  
So to follow up on this, Hadi has contacted me with the message below, and several documents (attached).

His message to me:

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Attached, please find three attached documents from 2019, when Prof. Levy was CCC Representative from ME department. After receiving the attached syllabus of ME Optimization courses (zip file), we had a few meetings and finally CCC agreed to move forward with the course proposal approval. I also have attached the email from the CCC Chair that the course is approved.

with the course proposal approval. I also have attached the email from the CCC Chair that the course is approved.

The main supporting document is the CCC chair's approval that implied approval of all CEC departments to accept the course proposal in 2019. I hope this helps.

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Please let me know if this is enough to approve. Thanks!  
-Trevor

On Wed, Feb 16, 2022 at 7:31 AM Arvind Agarwal <[agarwala@fiu.edu](mailto:agarwala@fiu.edu)> wrote:

Trevor,

I searched all my emails and tried hard but do not recall this discussion earlier. Maybe I am missing something. Can you please ask Hadi to connect with me?

Jason: Did we ever discuss this in our meetings?

Thanks

**Arvind Agarwal, Ph.D., FASM, FACerS, FAAAS**  
*Chair and Distinguished University Professor*  
[Mechanical and Materials Engineering](#)  
Director, [Advanced Materials Engineering Research Institute \(AMERI\)](#)  
College of Engineering and Computing  
Florida International University  
10555 West Flagler Street, EC 3474  
Miami, FL 33174  
P: (305) 348-1701 | F: (305) 348-1932 | E: [agarwala@fiu.edu](mailto:agarwala@fiu.edu)  
<http://pfl.fiu.edu>  
<http://ameri.fiu.edu>

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**From:** Trevor Cickovski <[movingpictures83@gmail.com](mailto:movingpictures83@gmail.com)>  
**Sent:** Tuesday, February 15, 2022 6:21 PM  
**To:** Arvind Agarwal <[agarwala@fiu.edu](mailto:agarwala@fiu.edu)>  
**Subject:** Please confirm you approve

**Note: This message originated from outside the FIU Faculty/Staff email system.**

Dear Arvind:  
Hadi Amini says he previously discussed the attached course with you.

The computer science department has already approved the attached course description. We

The computer science department has already approved the attached course description. We require a confirmation that you have no objection to us offering this course due to some limited overlap with ME.

The course is already being offered at the graduate level (three times), and the syllabus has been approved as mentioned.

A quick "yes" or "no" will suffice. Thanks!  
-trevor

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*****
Trevor Cickovski
Associate Teaching Professor of Computer Science
CASE280D
Florida International University
11200 SW 8th Street
Miami, FL 33199
(305) 348-8043
tcickovs@fiu.edu
"You learn more from missing a tough target than hitting an easy one."
*****
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*****
Trevor Cickovski
Associate Teaching Professor of Computer Science
CASE280D
Florida International University
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