University of Puerto Rico
Río Piedras Campus
College of Natural Sciences
Department of Mathematics

Course Syllabus
Second semester academic year 2018-19

Course information

Course title: Optimization
Course code: MATE 6882
Number of hours/credits: 45 hours/3 credits
Course prerequisites: MATE 5201 (Advanced Calculus) and knowledge of a high level programming language

Room: NCN II C-209
Time: Monday and Wednesday 4:00-5:20 pm
Course web pages: `https://online.uprrp.edu/course/view.php?id=31426` and `http://epsilon.uprrp.edu/mmarcano/cursos/Optimization/index.html`

Instructor: Mariano Marcano
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Office hours: Monday 11:00 am -1:00 pm and Wednesday 1:00-2:00 pm
Professor's web page: `http://epsilon.uprrp.edu/mmarcano`

Course description

This is a course on nonlinear optimization problems, both unconstrained and constrained. We will study optimality conditions and the basic numerical optimization methods with their convergence analysis. The numerical methods include: basic descent methods, conjugate direction methods, quasi-Newton algorithms, reduced gradient method, gradient projection method, penalty and barrier methods, duality, and Lagrange methods.

Course objectives

After completing the course students will know how to:

1. verify the optimality conditions for nonlinear optimization problems, both constrained and unconstrained;
2. apply basic numerical optimization methods;
3. evaluate the advantage and disadvantage of the basic optimization methods;

4. solve large size optimization problems by using the computer;

5. verify the convergence criteria of the basic optimization methods.

Content outline and schedule

	Topic	Time
1.	Optimality conditions for unconstrained problems.	3 hours
2.	Convexity.	1.5 hour
3.	Basic descent methods:	6 hours
	(a) line search (1.5 hour);	
	(b) steepest descent (3 hours);	
	(c) and Newton's method (1.5 hour).	
4.	Assignment 1 (tentatively: Wednesday, February 13)	
5.	Conjugate direction methods.	6 hours
6.	Assignment 2 (tentatively: Wednesday, February 27)	
7.	Quasi-Newton methods.	6 hours
	(a) The modified Newton's method (1.5 hour);	
	(b) Methods that construct the inverse of the Hessian matrix (1.5 hour);	
	(c) The Davidon-Fletcher-Powell method (1.5 hour);	
	(d) and The Broyden family of methods (1.5 hour).	
8.	Assignment 3 (tentatively: Wednesday, March 13)	
9.	Algorithms for Nonlinear Least-Squares Problems	1.5 hour
10.	Take-home exam I (tentatively: Wednesday, March 20)	
11.	Global optimization:	6 hours
	(a) Monte Carlo (1.5 hour);	
	(b) metropolis algorithm and simulated annealing (3 hours);	
	(c) and genetic algorithms (1.5 hour).	
12.	Assignment 4 (tentatively: Wednesday, April 3)	
13.	Optimality conditions for constrained problems with equality and inequality.	6 hours
14.	Primal methods.	3 hours
15.	Assignment 5 (tentatively: Wednesday, April 24)	
16.	Penalty and barrier methods.	3 hours
17.	Trust-region methods.	3 hours
18.	Assignment 6 (tentatively: Wednesday, May 1)	
19.	Take-home exam II (tentatively: Friday, May 10)	
	Total:	45 horas

Instructional strategies

- The course will be taught in the classroom and online. The content of the course and supporting materials will be available to the student through the Moodle platform. The lecture notes will be in slide presentations.
- Assignments will be uploaded to Moodle in pdf format, the students will download the files and, before the deadline, the students must upload the answers to Moodle in a single file. Grading and feedback will be available in Moodle to the student.
- A frequent asked question FAQ Moodle forum will be available to post any question the student may have and answer questions posted by classmates. One point bonus (maximum two points) will be added to the corresponding homework of any student that answers completely and correctly a question of the forum.
- As alternative methods that do not require the physical presence of the students and the teacher in the classroom, we will use: discussion forums, recorded lectures, and video conferences.

Course policies

- Course evaluation is based on homework assignments and take-home exams, thus students must not have conflicts with the exam time.
- *Alternative Teaching Methods*. Certification No. 112 (2014-2015) of the Governing Board defines a classroom course as a course in which 75% or more of the hours of instruction require the physical presence of the students and the teacher in the classroom. This means that 25% of a classroom course could be offered without requiring the physical presence of the students and the teacher in the classroom. If necessary, this course will be able to complete up to 25% of the contact hours (11.25 hours) on a non-face-to-face basis by alternative methods such as: Video-conferences, instructional modules, discussion forums and others. If so, the calendar/agenda will be modified to include the topics that will be covered by alternative methods.

Available and required learning resources

To take advantage of the course material and other resources in Moodle the student needs a personal computer with fast internet access, a PDF viewer, an internet browser, a word processor (LaTeX is free and suitable for writing mathematical expressions), and a high level programming platform equipped with a library of numerical methods: MATLAB/Octave, Python, or R. Octave is free and can be downloaded from `http://www.gnu.org/software/octave/download.html`.

Course evaluation

Evaluation of student understanding of the class material will be made by means of homework assignments and take-home exams. The grade will be computed as follows:

Assignments	40%
Exam I	30%
Exam II	30%
	100%

Assignments will be posted in Moodle at least one week before the deadline.

Grading system

Letter system (A, B, C, D or F).

Law 51: Rights of Students with Disabilities

Students with access to Vocational Rehabilitation Services should contact the professor at the beginning of the semester in order to plan any special arrangements and equipment necessary in accordance with the recommendations of the Office of Challenged Students' Affairs (OAPI) in the Office of the Dean of Students. In addition, any students with special needs or who require any type of assistance or special arrangements should contact the professor.

Academic Integrity

The University of Puerto Rico promotes the highest standards of academic and scientific integrity. Article 6.2 of the UPR Students General Bylaws (Board of Trustees Certification 13, 2009-2010) states that academic dishonesty includes, but is not limited to: fraudulent actions; obtaining grades or academic degrees by false or fraudulent simulations; copying the whole or part of the academic work of another person; plagiarizing totally or partially the work of another person; copying all or part of another person answers to the questions of an oral or written exam by taking or getting someone else to take the exam on his/her behalf; as well as enabling and facilitating another person to perform the aforementioned behavior. Any of these behaviors will be subject to disciplinary action in accordance with the disciplinary procedure laid down in the UPR Students General Bylaws.

Normativeness on discrimination by sex and gender in sexual violence form

The University of Puerto Rico prohibits discrimination based on sex, sexual orientation, and gender identity in any of its forms, including that of sexual harassment. According to the Institutional Policy Against Sexual Harassment at the University of Puerto Rico, Certification Num. 130, 2014-2015 from the Board of Governors, any student subjected to acts constituting sexual harassment, must come to the Office of the Student Ombudsperson,

the Office of the Dean of Students, and/or the Coordinator of the Office of Compliance with Title IX for an orientation and/or a formal complaint.

Textbook: David G. Luenberger and Yinyu Ye. *Linear and Nonlinear Programming (International Series in Operations Research & Management Science*. Third Edition, Springer, 2008. ISBN 978-0-387-74503-9

Bibliography

1. Mokhtar S. Bazaraa, Hanif D. Sherali, and C. M. Shetty, *Nonlinear Programming: Theory and Algorithms,* Second Edition, John Wiley & Sons, New York 1993.

2. John E. Dennis and Robert B. Schnabel, *Numerical Methods for Unconstrained Optimization and Nonlinear Equations,* SIAM,Philadelphia, 1996.

3. Anthony V. Fiacco and Garth P. McCormick, *Nonlinear Programming: Sequential Unconstrained Minimization Techniques,* SIAM. Philadelphia, 1990.

4. Phillip E. Gill, Walter Murray, and Margaret H. Wright, *Practical Optimization,* Academic Press, New York, 1989.

5. Olvi L. Mangasarian, *Nonlinear Programming,* SIAM, Philadelphia, 1994.

6. Michalewicz, Z. *Genetic Algorithms + Data Structures = Evolution Programs*. Third Edition, Springer-Verlag, New York, 1997.

7. A. Neumaier, Complete Search in Continuous Global Optimization and Constraint Satisfaction, in: *Acta Numerica* (A. Iserles, ed.), Cambridge University Press, 271-369, 2004.

8. Jorge Nocedal and Stephen J. Wright. *Numerical optimization*. Springer, 1999.

9. Peter Salamon, Paolo Sibani, and Richard Frost. *Facts, Conjectures, and Improvements for Simulated Annealing*. SIAM, 2002.

Electronic references

1. M. Marcano, *Introduction to* MATLAB, preprint, 2007, `http://epsilon.uprrp.edu/mmarcano/cursos/Computational_Analysis/Presentations/MatlabIntroduction.pdf`.

2. Negrón, P. V., *Un Vistaso a* MATLAB, preprint, 2006 `http://mate.uprh.edu/~pnegron/notas4061/intro_matlab/index.htm`.

3. I. Rubio, *Una introducción breve a LaTeX*, preprint, 2011, `http://ccom.uprrp.edu/actividades/IntroLatex.pdf`.