UNIVERSITY OF PUERTO RICO
MAYAGÜEZ CAMPUS
COLLEGE OF ENGINEERING
INDUSTRIAL ENGINEERING DEPARTMENT

COURSE SYLLABUS

General Information

Course Number: ININ 5005
Course Title: **Modern Optimization Methods**
Credit-Hours: Three (Three hours of lecture per week)

Course Description

Advanced undergraduate course addressed to Industrial Engineering students to studies the most common heuristic search methods. Topics such as simulated annealing, genetic algorithms, tabu search, and combinatorial and continuous optimization problems are disscused. The main techniques and their variations presented and are critically discussed. Key papers from the literature, including applications, are discussed.

Pre-requisites

ININ 4021 (Deterministic Models in Operations Research) or authorization of the Director of the Department of Industrial Engineering

Textbook and References

- R.L. Haupt and S. E. Haupt. Practical Genetic Algorithms. John Wiley, 1998; and
- W.L. Winston. Operations Research. Applications and Algorithms. 4th Edition. Duxbury. 2004; or
- W.L. Winston and M. Venkataramanan. Introduction to Mathematical Programming. Brooks/Cole. 2003
- M. Gen and R. Cheng. Genetic Algorithms & Engineering Optimization. John Wiley & Sons, NY 2000.
- K.F. Man, K.S. Tang and S. Kwong, Genetic Algorithms, concepts and designs, Springer Verlag, London 1999.
- Z. Michalewicz and D.B. Fogel. How to solve it: Modern Heuristics, Springer Verlag, London, 1999.
- Rayward-Smith, et al. (editors). Modern Heuristic Search Methods. John Wiley & Sons, NY, 1996.
- Z. Michalewicz. Genetics Algorithms + Data Structures = Evolution Programs. WNT, Warsaw 1996.
- D.B. Fogel. Evolutionary Computation. IEEE Press, New York, 1995.
- C. Reeves. Modern Heuristic Techniques for Combinatorial Problems. John Wiley & Sons, NY, 1993.
- R. Azencott (editor). Simulation Annealing. John Wiley & Sons, NY, 1992.
- J.R. Koza. Genetic Programming. MIT Press, 1992.

- L. Davis (Ed.). Handbook of Genetic Algorithms. Van Nstrand Reinhold, New York, 1991.
- E. Aarts and J. Korst. Simulated annealing and Boltzmann machines, John Wiley & Sons, Chichester 1989.
- D.E. Goldberg. Genetic Algorithms in Search, Optimization and Machine Learning, Addison-Wesley, 1989.
- L. Davis. Genetic Algorithms and Simulated Annealing. Pitman, London, 1987.
- J.H. Holland. Adaptation in Natural and Artificial Systems. The University of Michigan Press, Ann Arbor, 1975.

Up to date information in this area can be found in the following journals:

- *Annals of Operations Research.*
- *Computers & Operations Research.*
- *Evolutionary Computation.*
- *IEEE Transactions on Evolutionary Computation.*
- *IIE Transactions.*
- *INFORMS Journal on Computing.*
- *Journal of Heuristics.*
- *Proceedings of the IEEE International Conferences on Evolutionary Computation (1994-present).*
- *Proceedings of the International Conferences on Genetic Algorithms (1987-present)*

Purpose

This is a course primarily designed for advanced undergraduate and graduate students whose major concentration is industrial engineering or management systems. It is also appropriate for engineering and mathematics graduate students with a basic knowledge of linear programming and optimization techniques interested in transportation analysis, communications, distribution and logistics, sequencing and scheduling, and combinatorial-optimization problems.

The purpose of the course is to prepare students (i) for mastering the theories and most common heuristic algorithms; (ii) for recognizing real-world situations that can be modeled and solved using heuristic methods; and (iii) for applying modern heuristic search methods in their final design projects or thesis work.

Grading

Final grades will be assigned based on a curve that will take into account: i) the course objectives; ii) the difficulty and complexity of the assignments, projects, and exams; and iii) your relative performance in the assignments, projects, and exams; and your class participation.

Course Goals

After completing the course students should

1. Know how heuristic techniques work, to be able to use them effectively.
2. Know when heuristic techniques should be applied, to be able to use then appropriately.
3. Know heuristic techniques' relative merits to each other, and to the more traditional approaches

of mathematical programming, to be able to discern which one to use in a particular case.
4. Apply heuristic techniques to solve difficult (usually, combinatorial) optimization problems.
5. Analyze heuristic techniques and make intelligent decisions on their parameter values.

In addition, this course supports the following IE program outcomes

A. Improve students' ability to apply knowledge of mathematics, science, and engineering.
B. Improve students' ability to design a system or process to meet desired needs.
C. Develop students' ability to function in teams.
D. Enhance students' ability to identify, formulate, and solve engineering problems.
E. Enhance students' ability to communicate effectively.
F. Recognize the need for, and develop an ability to engage in life-long learning.
G. Improve students' ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Requirements

All students are expected to:

- Do all assigned readings and related homework.
- Come to class prepared.
- Come to class all the time and on time.
- Complete a comprehensive team project.
- Pass all tests to receive credit for the course.

Department and Campus Policies

Class attendance: Class attendance is compulsory. The University of Puerto Rico, Mayagüez Campus, reserves the right to deal at any time with individual cases of non-attendance. Professors are expected to record the absences of their students. Frequent absences affect the final grade, and may even result in total loss of credits. Arranging to make up work missed because of legitimate class absence is the responsibility of the student (see Bulletin of Information Undergraduate Studies)

Absence from examinations: Students are required to attend all examinations. If a student is absent from an examination for a justifiable reason acceptable to the professor, he or she will be given a special examination. Otherwise, he or she will receive a grade of zero of "F" in the examination missed (see Bulletin of Information Undergraduate Studies).

Final examinations: Final written examinations must be given in all courses unless, in the judgment of the Dean, the nature of the subject makes it impracticable. Final examinations scheduled by arrangements must be given during the examination period prescribed in the Academic Calendar, including Saturdays (see Bulletin of Information Undergraduate Studies).

Partial withdrawals: A student may withdraw from individual courses at any time during the term, but before the deadline established in the University Academic Calendar (see Bulletin of Information Undergraduate Studies).

Complete withdrawals: A student may completely withdraw from the University of Puerto Rico, Mayagüez Campus, at any time up to the last day of classes (see Bulletin of Information Undergraduate Studies).

Law 51 (Disabilities): All the reasonable accommodations according to the Americans with Disability Act (ADA) Law will be coordinated with the Dean of Students and in accordance with the particular needs of the student. After been identified with the professor and the institution, the students with disabilities will receive reasonable accommodations in their courses and evaluations. For more information, please contact *Student Services with Disabilities* at the Student Dean's Office at (Q-019), 787-265-3862 ó 787-832-4040 x-3250 ó 3258.

Ethics: Any academic fraud is subject to the disciplinary sanctions described in article 14 and 16 of the revised General Student Bylaws of the University of Puerto Rico contained in Certification 018-1997-98 of the Board of Trustees. The professor will follow the norms established in articles 1-5 of the Bylaws.

The Director make sure that students registering for the course have

- A basic understanding of mathematical programming.
- An ability to develop mathematical models for real problems.
- Programming skills of some sort (MatLab, C, C++, VisualBasic, Pascal…). Programming will be required to implement the optimization methods. This will be done on PCs.

General Topics

Period	Subject	Readings
1-3	Introduction to optimization and mathematical programming. Review of formulation of linear programming problems. Solution of LP problems using standard packages.	Winston, Ch. 3.
4-6	Review of network models. The transshipment problem. The minimum cost network flow problems.	Winston, Chs. 7 & 8
7-9	Review of integer programming. Branch and bound. The knapsack problem. The traveling salesman problem.	Winston, Ch. 9.
10-12	Introduction to nonlinear optimization and to heuristic search.	Haupt[2] Chs. 1 & 2
13-15	Genetic algorithms.	Haupt[2] Chs. 2 & 3
16-18	More on genetic algorithms and simple applications.	Haupt[2] Chs. 4 & 5
19-21	**1st review, assessment, and feedback**	

22-24	Advanced applications of GA: Traveling salesman, location problems…	Haupt[2]. Ch. 6.
25-27	Simulated Annealing.	Rayward-Smith, et al. Chs. 1 and 2. Class notes
28-30	Simulated Annealing. Applications: Flight scheduling problem, the freight train regrouping problem…	
31-33	Tabu search.	Rayward-Smith, et al. Chs. 10. Class notes
34-36	Tabu search. Applications.	
37-39	**2nd review, assessment, and feedback**	
40-42	Student project presentations	
43-45	Self-tuning and hybrid methods.	Class notes

INSTRUCTOR INFORMATION SHEET

General Information

Instructor: Noel Artiles-León, Ph.D.
Title: Professor
Office: II-216
Phone: 787-265-3819
Office Hours: TBA
E-mail / URL: nartiles@uprm.edu

Course Number: ININ 5yyy
Course Title: Modern Optimization Methods
Course Description

Advanced undergraduate course addressed to Industrial Engineering students to studies the most common heuristic search methods. Topics such as simulated annealing, genetic algorithms, tabu search, and combinatorial and continuous optimization problems are disscused. The main techniques and their variations presented and are critically discussed. Key papers from the literature, including applications, are discussed.

Additional References

Journals:

- *Annals of Operations Research.*
- *Computers & Operations Research.*
- *Evolutionary Computation.*
- *IEEE Transactions on Evolutionary Computation.*
- *IIE Transactions.*
- *INFORMS Journal on Computing.*
- *Journal of Heuristics.*
- *Proceedings of the IEEE International Conferences on Evolutionary Computation (1994-present).*
- *Proceedings of the International Conferences on Genetic Algorithms (1987-present).*

Assessment

This course is an advanced undergraduate course with some emphasis on self exploration. There will be

- Homework assignments (20%)……almost weekly
- First partial exam (20%)……...date TBA
- Second partial exam (20%)…….date TBA
- Team project or paper review (20%)…….date TBA
- Final exam (20%)…….date TBA by Registrar's Office

  Note: A student must get at least 65% in each of the tests to receive credit for the course.

The project can analyze multiple techniques or be an in-depth exploration of one technique using problems and applications of the students' choice. These techniques are flexible enough to accommodate a variety of applications in classic OR, manufacturing systems, engineering design, transportation and logistics. The project may be based on one or more articles from one of the subjects we cover in class. Each team will be responsible for providing a written report to the instructor and an oral tutorial on the articles to the class during the appointed class period. (Tell why these articles are relevant to what was discussed in the course. What was the objective of the articles? What research was carried out? How well was it presented and documented? Did the results support the premise of the articles? Were the arguments convincing, or did more or better work need to be done? How could the results of these articles be used? How much of a contribution to the field do they make?... Any other reactions you have to the articles). If you experience difficulties selecting the articles, please discuss it with me and I will help you make a decision.

- **Partial exams are optional**. If you decide not to take a partial exam (for any reason or circumstance) the grade that you get in your final exam will be assigned to the missing exam. The assignments and the final exam are not optional. Exams will be returned graded by the professor within one week.

- **All exams are comprehensive.** This means that the material to be examined on the second test, includes the material examined on the first one; and that the material to be examined on the final test, includes the material examined on the first and second tests.

- Because the comprehensive nature of the tests, a student can replace the grade obtained on the first test by the average of the first two tests; for example, if she takes the first test and gets 60 points (out of 100) and she takes the second test and gets 92 points, then she may choose to replace the grade in the first test (60) by the average of these two tests (60+92)/2=76. Similarly, a student can replace the grade obtained on the second test by the average of the second and final tests.

- All assignments must include detailed descriptions of the problems that are being solved. Assignments are graded based on technical merits and accuracy. You will not get extra credit for fancy printing or expensive covers; consequently, spend most of your time addressing technical aspects.

- Final grades will be assigned based on a curve that will take into account: i) the course objectives; ii) the difficulty and complexity of the assignments, projects, and exams; and iii) your relative performance in the assignments, projects, and exams; and your class participation.

Instructional Strategy

Lectures: The professor will spend about 50% of the time lecturing. Several lectures will take place in the IE computer center to illustrate the implementation of heuristic methods in modern software packages.

Class discussions are strongly encouraged to provide a deeper understanding about the topics presented during a lecture. Class discussions should take about 25% of class time.

Problem solving: cussions are strongly encouraged to provide a deeper understanding about the topics presented during a lecture. Class discussions should take about 25% of class time.

Problem solving: About 25% of class time will be spent on problem solving.

Deadlines for Assignments and reports

Assignments and reports must be handed in on the dates indicated. The grade of late assignments and reports will be lowered by 10% points for each calendar day (or fraction) that they are late.

Cheating and Plagiarism

Plagiarism is passing off someone's work as your own with the willful intention to cheat. Examples of cheating and plagiarism include copying all or part of an assignment, project report, or exam from a classmate, getting together to work on an individual assignment, talking to a classmate during a test the use of unauthorized notebooks, books, or other sources during a test, the unauthorized copying of examinations, assignments, reports, or the presentation of unacknowledged material as if it were the student's own work. **Any work submitted by students must be their own**. Cheating, plagiarism, or doing work for another person which will receive academic credit is not permissible. In the case of collaborative work, it is certainly permissible to have appropriate interactions; however, unless instructions explicitly state otherwise, students will prepare their own separate and individual assignments, exams, and reports. Under no circumstances, take-home exams (if any) are collaborative, and, during the take-home frame, there will be no discussion of the exam questions with anyone other than the professor. All assignments and exams in this course are supposed to be done individually. Project reports are to be done in teams; consequently, the interaction within a team is not only appropriate but highly desirable. However, interaction between teams will be considered plagiarism. If a student engages in cheating or plagiarism (copying or passing information), he/she will get an F in the class and will be reported to university authorities for the proper disciplinary action.