ENMA 703/803
OPTIMIZATION METHODS

Spring 2012
Monday 7:10 – 9:50 PM
Broadcasted from Kaufman Hall, Room 247

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Office Hours:	Monday and Thursday, 4 to 6 PM, or preferably by appointment.
Instructor Web Site:	http://www.odu.edu/~grabadi/
Class Web Site:	http://blackboard.odu.edu/
Adobe Connect Web Site:	http://connect.odu.edu/enma703

How to Login: See the **Blackboard** section in this syllabus

Login to Blackboard frequently for notes, downloads, announcements etc.

COURSE OBJECTIVES

The objective of this course is to introduce the students to various optimization modeling frameworks and methods including Exact, Approximate, and Meta-Heuristic methods for discrete optimization problems. Problems addressed include linear and nonlinear discrete optimization problems in various areas of application. The main focus of the class will be on modeling and solving such problems using classic and modern optimization methods. The theory, rationale, and applications of various optimization methods will be discussed. Methods that will be covered include but not limited to Branch and Bound, Local Search, Greedy Algorithms, Evolutionary Methods, Genetic Algorithms, Simulated Annealing, Tabu Search, Constraint Programming and Squeaky Wheel Optimization.

COURSE PREREQUESITS

1. ENMA 603 (Operations Research), or MSIM 651 (Analysis I) or an equivalent course in Operations Research is a prerequisite for this class. Students are assumed to have good knowledge of Operations Research including topics such as Linear Programming, Integer Programming, Operations Research Modeling (objective functions, constraints, and decision variables), Network models etc) among other Operations Research classical concepts and methods.
2. Knowledge of computer programming will be necessary (see the Software and Computer Skills Section)

CLASS FORMAT

This class will be in a **hybrid format** (synchronous and asynchronous) where students are expected to preview certain video lectures that will be available prior to class time. Most sessions will be synchronous and will take the form of interactive on-campus lectures at ODU and at the same time will be streamed real-time online via Adobe Connect. The online sessions will also be interactive and students are expected to participate and ask questions at the same level like those attending the on-campus lecture. The interactive sessions (both on-campus and online) will in most cases be devoted to discussions, exercises, software tutorials, questions and answers about topics that are covered in the videos. Therefore, it is very important to watch and

study the videos and the asynchronous material prior to the live lectures according to the schedule provided at the end of this syllabus. In some cases, the interactive sessions may be held on-line via Adobe Connect for all students. Therefore it is important for everyone in this class to be familiar with the Adobe Connect environment (Read the section on the use of Adobe Connect in this syllabus).

The schedule for the synchronous (live) and asynchronous (video) sessions are according to the tentative class schedule provided with this syllabus. Changes to the schedule will be announced during the semester.

CLASS MATERIAL, TEXTBOOKS, AND INFORMATION SOURCES

There will be no assigned textbook for this class. Information presented in this class will be based on a collection of instructor notes, book chapters, research articles, tutorials, and exercises that will be provided via Blackboard. Additionally, a list of references is provided in this syllabus, and will be updated regularly during the semester. Students *are expected* to seek these and other books, articles, and web sites on their own to fully understand the concepts introduced and discussed in this class. Research papers will be used quite often and students will be expected to take a research-based approach to learning. By the end, you will not only learn about Optimization topics, but will also learn how these topics are conducted for research, and will have to do a lot of independent learning. The library at Old Dominion University provides students with access to many electronic and physical technical journals and books related to the topics presented in this class.

Slides, notes, tutorials, papers, etc. will be posted on blackboard prior to class lectures along with videos. However, in the synchronous (live) sessions, there will be a lot of graphs, mathematical models, exercises and equations presented, and therefore, it is recommended that students take their own notes. It is still expected for students to log into Blackboard before class for updates and downloads, which I will do my best to have available one day prior to class. Videos, however, will be provided several days ahead of time to allow enough time for viewing and studying.

SOFTWARE AND COMPUTER SKILLS

- This course entails designing, developing, and implementing models, algorithms and computer procedures. Therefore, the knowledge of a computer programming language will be necessary. That is, students should at least be able to define variables and arrays, construct IF-THEN-ELSE statements, DO loops, WHILE loops, etc in any computer programming language (Basic, C, C++, JAVA, Fortran, etc). In many cases, code and/or software may be provided and the students are expected to modify it or experiment with it. While extensive knowledge of programming is not necessary, basic knowledge will be important to write algorithms and/or pseudo code. See Assignment 1 on Blackboard to get some idea

- The knowledge of MS-Excel is assumed. MS-Excel *Solver* will also be discussed and used. Therefore, make sure you have access to a recent version of Excel with *Solver* (preferably MS-Excel 2010). A free and robust Linear Solver that works with MS-Excel is freely available at http://opensolver.org/ and I recommend for everyone to download and install it. Instructions on downloading, installing and using *OpenSolver* are available on the same web site. Keep in mind that this solver handles linear problems only.

- An alternative to MS-Excel *Solver* is to use the free Solver that comes with *OpenOffice*, which is an open source software similar to MS-Office (Word, Excel, PowerPoint and Access) with similar functionality. *OpenOffice* is available at http://www.openoffice.org/. Other software packages may be used and information regarding such packages will be furnished during the semester.

- Assignment and project reports must be typed. So you should be comfortable with word processing software such as MS-Word or software that is compatible with it such as *OpenOffice*.

- To view the videos posted for this class you need XVid Codec program. You can download it by searching for "xvid codec download" and download and install it. Here is a direct link to the page: http://www.xvidmovies.com/codec/

HOMEWORK ASSIGNMENTS, AND PROJECTS

- There will be no exams in this class. There will be individual assignments and an individual term project for students in ENMA703 in addition to an optimization research paper or assignment for ENMA803 students (i.e., Ph.D. students).

- The nature of the assignments and project will be solving problems, developing models, coming up with examples to meet certain requirements, implementing computer models or programs, etc. All assignments will be posted and collected during the semester on Blackboard.

- The term project will be assigned during the semester to solve an optimization problem. The project will entail designing, developing and implementing an optimization model(s) and/or algorithm(s) for the problem provided. A report including the work performed and the results obtained is required.

GRADE DISTRIBUTION

ENMA 703 (Master students)	
Assignments	75%
Term Project	25 %
ENMA 803 (Doctoral students)	
Assignments	65%
Term Project	25 %
Research paper/assignment	10%

GRADING SCALE

90-92	A-	93-100	A		
80-82	B-	83-86	B	87-89	B+
70-72	C-	73-76	C	77-79	C+
< 70	F				

ACADEMIC INTEGRITY
The Old Dominion honor system is in effect for all student work submitted during the course. In effect, this stipulates that lying, cheating or plagiarism are violations of the honor system and will be subject to disciplinary action. Violation of the honor code will not be tolerated. The punishment ranges from getting "F" in the course to being expelled.

CLASS ATTENDANCE
Class attendance for the synchronous (live) sessions is "expected". If for some reason a student should miss a class, it is the *student's responsibility* to:

1. Inform themselves of any administrative announcements (e.g. schedule changes) discussed during a session.
2. "Make-up" any of the course material covered in the session. This is of particular importance as there will be work presented in the sessions that may not be covered adequately in the textbook.

It is not necessary to inform me of an absence should a situation arise where attendance is not possible. Please note however, that *I reserve the right not to provide extensive information about what transpired in a class*.

EMAIL
I will be communicating with all students using both Blackboard announcements and ODU email addresses. So, you need to activate your ODU email login and password. If you have not activated your student e-mail account, go to http://occs.odu.edu/accounts/studemail/. If you send me an email from an address other than your ODU email account, I will reply to it. However, whenever I initiate an email message, I will use your ODU email address.

USING BLACKBOARD:

1. Access the system at: http://blackboard.odu.edu/
2. It is a requirement of all Blackboard courses that you have an Old Dominion University Student MIDAS account to access Blackboard. If you do not have a Midas account, you can request one at https://midas.odu.edu. Be prepared to complete the security profile in the event you lose or forget your password in the future. *It may take several hours for the information about a new account or password to become active in Blackboard, Therefore, please allow up to 24 hours before reporting any login problems to Customer Service.*
3. To upload your assignments, a link becomes active after the assignment is posted.
4. If you never used Blackboard before, visit and read the student help page which could be found at:

   http://www.odu.edu > Current Students > Blackboard > Student Help

ADOBE CONNECT
Adobe Connect is an On-line interactive environment to attend live sessions online. Students can interact via chat, voice and video. To attend online using Adobe Connect you need the following:

- a computer (Laptop or a desktop)
- a reliable high speed internet connection like DSL, cable or LAN.
- a microphone and speakers (or preferably a headset)

- a web browser (Preferably the Chrome browser, which can be downloaded for free at www.google.com/chrome)
- There will be no need to install other software
- Class web site can be accessed at http://connect.odu.edu/enma703
- Upon your login to Adobe Connect for the first time, you need to install the latest Flash Player by going to:

  Help >> Troubleshooting

  It is also recommended to make sure your microphone and speakers are working by going to
  - Meeting >> Audio Setup Wizard

- Adobe Connect documentation is available on Blackboard under:
  - Modules >> Adobe Connect.

SPRING 2012 ACADEMIC CALENDAR
http://www.odu.edu/ao/registrar/calendars/academic/spring.shtml

- Spring classes begin, January 7 (our first class is on January 9)
- SPRING TUITION DEADLINE JANUARY 9, 2012
- Martin Luther King, Jr. Holiday, January 16
- DEADLINE TO DROP/ADD CLASSES, January 17
- Spring Holiday, March 5-10
- Withdrawal Deadline, March 27
- Spring classes end, April 24
- Exams period is April 26 to May 3
- Spring Commencement, May 5

TENTATIVE CLASS SCHEDULE

Date	Week	Topics	Format*	Reference Material
Jan 9	1	Course Overview Introduction to Optimization Problems Introduction to Scheduling Optimization Assignment 1 is available (Due on Monday January 16)	Live Live Video	Syllabus Michalewicz (2000), Ch1 Any discrete optimization text Pinedo (2008) on Scheduling Assignment 1 on Blackboard
Jan 16	2	Martin Luther King Day Assignment 1 is due on Blackboard	No Class	No Class
Jan 23	3	Conceptual Framework for Solving Optimization Problems Problem and Algorithm Complexity Assignment 2 is available and is due on Wednesday February 1	Video Live	Michalewicz (2000) p.16-23 Harel (1992), Ch 7 Michalewicz (2000) Rabadi et al (2004) p.1727-1731 Rabadi et al (2007) p. 326-329 Assignment 2 on Blackboard
Jan 30	4	Exact Optimization Methods Branch and Bound for Integer programs Exact Optimization Methods Discussion Integer Program Models Assignment 3 is available and is due on Monday Feb 13	Video Video Live Live	Tutorial on Branch and Bound for Integer Programs Assignment 3 on Blackboard
Feb 6	5	Tailored Branch and Bound Algorithms Discussion	Video Live	Pinedo and Chao (1998) Rabadi et al. (2004)
Feb 13	6	Local Search and Greedy Algorithms Simulated Annealing Introduction Assignment 4 is available and is due on Wednesday February 22	Live Video	Michalewicz (2000) Tutorial on Simulated Annealing Rabadi et al (2007) Assignment 4 on Blackboard
Feb 20	7	Simulated Annealing Inner working Simulated Annealing Parameter Tuning and Discussion	Video Live	Tutorial on a Simulated Annealing Program Rabadi et al (2007)
Feb 27	8	Introduction to Evolutionary Systems Evolutionary Systems Strategies Example Evolutionary Systems Discussion Assignment 5 is available and is due on Monday March 12	Live	De Jong (2006) Assignment 5 on Blackboard

March 5	**9**	**Spring Break (No Class)**		**Spring Break (No Class)**
March 12	10	Evolutionary Systems Types Introduction to Genetic Algorithms Genetic Algorithms Program Assignment 6 is available and is due on Wednesday March 21	Live Live Video	De Jong (2006) Tutorial on Genetic Algorithms Tutorial on Genetic Algorithms Program Assignment 6 on Blackboard
March 19	11	Genetic Algorithms Inner working Genetic Algorithms Applications Genetic Algorithms Discussion Project is available and is due on Wednesday April 23 Research Assignment for Ph.D. students is available and is due on Wednesday April 11	Live	Tutorial on Genetic Algorithms Sastry, Goldberg and Kendall (2005) Project Description on Blackboard Research Assignment Description on Blackboard
March 26	12	Tabu Search Introduction Tabu Search Inner working Tabu Search Discussion	Video Live Live	Glover and Laguna (ch 3) Glover and Laguna (tutorial)
April 2	13	Constraint Programming Squeaky Wheel Optimization (SWO)	Live via Adobe Connect only	Constraint Programming Tutorial SWO Tutorial
April 9	14	Meta-heuristic for Randomized Priority Search (MetaRaPS)	Live	Rabadi et al (2006) Meta-RaPS tutorial
April 16	15	Wrap-up and overall discussion		
April 23	16	Term Project Due		No Class

*Format can be either synchronous (live) or asynchronous (video)

Recommended References (this list will be updated during the semester)

Burke, E. K.; Kendall, G. (Eds.) (2006), Search Methodologies: Introductory Tutorials in Optimization and Decision Support Techniques

De Jong, K. (2006) *Evolutionary Computation: A Unified Approach*, MIT Press (see web site below)

Harel, D. (1992) *Algorithmics: The sprit of computing*, Adison-Wesley

Goldberg (1989), *Genetic Algorithms* in Search, Optimization and Machine Learning,

Michalewicz and Fogel (2000) *How to Solve it: Modern Heuristics*, Springer

Pinedo (2008). Scheduling theory, algorithms and systems. Second edition, Prentice Hall.

Talbi (2009). Metaheuristics: From Design to Implementation

Arnaout, J-P, Rabadi, G. and Musa, R. (2010) "A Two-stage Ant Colony Optimization to Minimize the Makespan on Unrelated Parallel Machines with Sequence-Dependent Setup Times", Vol. 21, No. 6, P. 693 – 701, Available On-Line, DOI10.1007/s10845-009-0246-1, *Journal of Intelligent Manufacturing*

Rabadi, G., Anagnostopoulos, G., and Mollaghasemi, M. (2007), "A Heuristic Algorithm for The Just-In-Time Single Machine Scheduling Problem With Setups: A Comparison With A Simulated Annealing", *The International Journal of Advanced Manufacturing Technology*, Vol. 32, No. 3-4, P. 326 – 335.

Rabadi, G., Moraga, R., and Al-Salem, A. (2006), "Heuristics for the Unrelated Parallel Machine Scheduling Problem with Setup Times", *Journal of Intelligent Manufacturing*, Vol. 17, p. 85 – 97.

Rabadi, G., Mollaghasemi, M., and Anagnostopoulos, G.C., (2004) "A Branch-and-Bound Algorithm for the Early/Tardy Machine Scheduling Problem with a Common Due-Date and Sequence-Dependent Setup Time", *Computers & Operations Research Journal*, Vol. 31, No. 10, p. 1727-1751

Recommended Web Sites (this list will be updated during the semester**)**

Java code for De Jong, K. (2006): http://www.cs.gmu.edu/~eclab/projects/ec_courseware/

Algorithm Complexity: http://en.wikipedia.org/wiki/Big_O_notation

INFORMS (Institute for Operations Research and the Management Sciences)
www.informs.org

COIN-OR (Computational Infrastructure for Operations Research): http://www.coin-or.org/

Open-Source Resources are available at: http://www.coin-or.org/resources.html

Linear Programming FAQ
http://www-unix.mcs.anl.gov/otc/Guide/faq/linear-programming-faq.html

Nonlinear-programming FAQ
http://www-unix.mcs.anl.gov/otc/Guide/faq/nonlinear-programming-faq.html

More to be announced