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**Course Name and Number:** ISDA 609 - Mathematical Modeling Techniques for Data Analytics

**Credits:** 3 cr.

**Prerequisite(s):** [ISDA 600 – Information and Systems](http://sps.cuny.edu/courses/is_605);

[ISDA 605 - Fundamentals of Computational Mathematics](http://sps.cuny.edu/courses/is_605);

[ISDA 606 - Statistics and Probability for Data Analytics](http://sps.cuny.edu/courses/is_606).

**Course Description:** In this course students will learn mathematical methods for understanding data relationships and for system optimization. Mathematical modeling techniques for representing a complex system will be presented. Topics to be covered include difference, system of differential equations, linear (LP) and non-linear programming (NLP); algorithmic search methods for optimization; integer programming (IP), branch and bound, and their uses. Use of modeling packages will be stressed. Examples will be used from actual systems. In addition, students will be expected to explain their models, reports, and analyses in plain and easy-to-understand language.

**Course Learning Outcomes:**

By then end of the course, students should be able to:

* Learn linear programming models and theory; understand simplex method and apply to LP models; understand duality; be able to perform sensitivity analysis;
* Be able to formulate integer programming models; understand and apply branch and bound technique;
* Learn quadratic and nonlinear program models; know 2nd order condition and apply to QP; learn steepest descent method;
* Learn how to use commercial and free optimization tools.

**Program Learning Outcomes addressed by the course***:*

* Business Understanding. Apply frameworks and processes to build out data analytics solutions from understanding of business goals.
* Solid foundational data programming skills, using industry standard tools, essential algorithms, and design patterns for working with structured data, unstructured data and big data.
* Solid foundational math and statistics skills, with emphasis on linear algebra, probability, Bayesian statistics, and numerical methods.
* Data understanding. Collect, describe, model, explore and verify data.
* Data preparation. Selecting, cleaning, constructing, integrating, and formatting data.
* Optimization Modeling. Selecting optimization modeling techniques, generating test designs, building and assessing models.
* Model implementation and deployment. Machine learning
* Presentation. Evaluating and communicating results.

**How is this course relevant for IS professionals?**

Math modeling and optimization technics are essential for data analytics problems. It is the foundation for some problems that we will come across in linear regression, machine learning, and data mining fields. With understanding of math modeling techniques, IS and Data Analytics professionals would be able to solve many more real problems more efficiently and effectively.

**Assignments and Grading:**

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| --- | --- |
| **Participation (online discussion forums and communication with fellow students)\*** | **14%** |
| **Assignments (fourteen, equally weighted)\*\*** | **56%** |
| **Course Project (one project, team of 2)\*\*** | **30%** |
| **TOTAL** | **100%** |

\* Please actively participate in the online discussion each week about the homework, some discussion forums that the instructor provided, or projects. Please have at least **one substantial discussion** (express your views on the topic in discussion extensively) post in the discussion forum in order to get full mark.

\*\* Note that please do not submit your homework by email, please submit through the blackboard system. For each of the homework, only need to finish **three** selected problems of your own on the assigned list.

**\*\*\* Project description** is attached in the syllabus as well as in the blackboard system.

* Project proposal draft by end of week 9 (<1 page, please address the problem that your team is trying to solve) (October 25th, worth 10% of project grade)
* Final project proposal by end of week 11 (<1 page) (Nov 8th, 11:59pm EST, worth 10% of project grade)
* Project presentation slides due on Dec 10 8:00pm EST (Thursday)
* Project presentation starts on Dec 10 8:15pm EST (Thursday, worth 30% of project grade together with project presentation slides submission)
* Final project report (Dec 13th, 11:59pm EST, worth 50% of project grade)

|  |  |  |  |
| --- | --- | --- | --- |
| **Quality of Performance** | **Letter Grade** | **Range %** | **GPA/ Quality Pts.** |
| Excellent - work is of exceptional quality | A | 93 - 100 | 4.0 |
| A- | 90 - 92.9 | 3.7 |
| Good - work is above average | B+ | 87 - 89.9 | 3.3 |
| Satisfactory | B | 83 - 86.9 | 3.0 |
| Below Average | B- | 80 - 82.9 | 2.7 |
| Poor | C+ | 77 - 79.9 | 2.3 |
| C | 70 - 76.9 | 2.0 |
| Failure | F | < 70 | 0.0 |

**Required Texts and Materials:**

A First Course in Mathematical Modeling, 5th Edition. Frank R. Giordano, William P. Fox, Steven B. Horton. ISBN-13: 9781285050904

**Supplemental Texts and Materials:**

Practical Optimization: A Gentle Introduction

http://www.sce.carleton.ca/faculty/chinneck/po.html

Online book by Professor John W. Chinneck

**Relevant Software, Hardware, or Other Tools:**

Course will be using R for some of the computational homework and projects.

Please download and install R from here:

<http://cran.r-project.org/>

Please let the instructor know if you have any questions. The instructor will send you links for installing packages for R when needed.

**My Contact Information:**

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You are encouraged to ask me questions on the “Ask Your Instructor” forum on the course discussion board where other students will be able to benefit from your inquiries. I am available by email ([haiyuan.wang@sps.cuny.edu](mailto:haiyuan.wang@sps.cuny.edu)). We can also set up a Skype session for screen share. For the most part, you can expect me to respond to questions by email within 24 to 48 hours. If you do not hear back from me within 48 hours of sending an email, please resend your message.

**Course Outline:**

| **Unit** | **Topic** | **Readings** | **”To Do”** |
| --- | --- | --- | --- |
| **Week #1**  **Aug 27-30** | **An introduction to modeling and review of integration techniques** | Course Site  Features of Blackboard  Giordano et al: Chapter 1 & Appendix D | **Blackboard discussion**  **homework 1 is due by Sep 6th (Sunday 11:59pm)** |
| **Week #2**  **Aug 31-Sep 6**  Labor Day | **Modeling process, proportionality, and geometric similarity** | Giordano et al: Chapter 2 | **Blackboard discussion**  **homework 2 is due by EOW (Sunday 11:59pm)** |
| **Week #3**  **Sep 7-13** | **Model fitting and experiment modeling** | Giordano et al: Chapter 3 & 4 | **Blackboard discussion**  **homework 3 is due by EOW (Sunday 11:59pm)** |
| **Week #4**  **Sep 14-20** | **Simulation modeling** | Giordano et al: Chapter 5 | **Blackboard discussion**  **homework 4 is due by EOW (Sunday 11:59pm)** |
| **Week #5**  **Sep 21-27** | **Discrete probabilistic modeling** | Giordano et al: Chapter 6 | **Blackboard discussion**  **homework 5 is due by EOW (Sunday 11:59pm)** |
| **Week #6**  **Sep 30-Oct 4** | **Linear programming (LP) - problems, formulations and geometric interpretation, simplex method and sensitivity analysis** | Giordano et al: Chapter 7 | **Blackboard discussion**  **homework 6 is due by EOW (Sunday 11:59pm)** |
| **Week #7**  **Oct 5-11** | **Modeling using graph theory** | Giordano et al: Chapter 8 | **Blackboard discussion**  **homework 7 is due by EOW (Sunday 11:59pm)** |
| **Week #8**  **Oct 12-18**  Columbus Day | **Modeling with decision theory** | Giordano et al: Chapter 9 | **Blackboard discussion**  **homework 8 is due by EOW (Sunday 11:59pm)**  **Form team by end of week 8** |
| **Week #9**  **Oct 19-25** | **Game theory** | Giordano et al: Chapter 10 | **Blackboard discussion**  **homework 9 is due by EOW (Sunday 11:59pm)**  **Project proposal draft by EOW** |
| **Week #10**  **Oct 26-Nov 1** | **Modeling with a differential equation** | Giordano et al: Chapter 11 | **Blackboard discussion**  **homework 10 is due by EOW (Sunday 11:59pm)** |
| **Week #11**  **Nov 2-8** | **Modeling with systems of differential equations** | Giordano et al: Chapter 12 | **Final project proposal is due**  **Blackboard discussion**  **homework 11 is due by EOW (Sunday 11:59pm)**  **Project proposal by EOW** |
| **Week #12**  **Nov 9-15** | **Optimization of continuous models, nonlinear programming (NLP)** | Giordano et al: Chapter 13 | **Blackboard discussion**  **homework 12 is due by EOW (Sunday 11:59pm)** |
| **Week #13**  **Nov 16-22** | **Graphs of functions as models** | Giordano et al: Chapter 15 | **Blackboard discussion**  **homework 13 is due by EOW (Sunday 11:59pm)** |
| **Week #14**  **Nov 23-29**  Thanksgiving Recess | **Integer programming (IP)** | Chinneck: Chapter 12 | **Blackboard discussion**  **homework 14 is due by EOW (Sunday 11:59pm)** |
| **Week #15**  **Nov 30- Dec 6 and Dec 7-13** | **Final Project** |  | **Blackboard discussion**  **Project presentation slides due on Dec 10 7:30pm**  **Project presentation on Dec 10 7:45pm (Thursday)**  **Final project report due by Dec 13 11:59 PM** |

**Accessibility and Accommodations**The CUNY School of Professional Studies is firmly committed to making higher education accessible to students with disabilities by removing architectural barriers and providing programs and support services necessary for them to benefit from the instruction and resources of the University. Early planning is essential for many of the resources and accommodations provided. Please see:

<http://sps.cuny.edu/student_services/disabilityservices.html>

**Online Etiquette and Anti-Harassment Policy**

The University strictly prohibits the use of University online resources or facilities, including Blackboard, for the purpose of harassment of any individual or for the posting of any material that is scandalous, libelous, offensive or otherwise against the University’s policies. Please see: <http://media.sps.cuny.edu/filestore/8/4/9_d018dae29d76f89/849_3c7d075b32c268e.pdf>

**ACADEMIC INTEGRITY**Academic dishonesty is unacceptable and will not be tolerated. Cheating, forgery, plagiarism and collusion in dishonest acts undermine the educational mission of the City University of New York and the students' personal and intellectual growth. Please see: <http://media.sps.cuny.edu/filestore/8/3/9_dea303d5822ab91/839_1753cee9c9d90e9.pdf>

**STUDENT SUPPORT SERVICES**If you need any additional help, please visit Student Support Services:   
<http://sps.cuny.edu/student_resources/>

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**Course project description**

**Option 1:**

At the end of each chapter in the textbook, you can find a section titled “Projects”. Form a team with at least one other classmate and complete any three projects. It is desirable that the projects selected are from different chapters and use three different mathematical modeling methods. It is also highly desirable that you select one from the first five chapters, one from chapter six to chapter ten, and one from chapter eleven onward. Bonus points will be awarded for projects that go beyond the scope of the initial description. To qualify, please be specific in your final report and final presentation as to the extensions your team implemented.

**Option 2:**

Select any phenomena or real world problem of your choice, apply three mathematical modeling techniques to the problem, and present your findings clearly in your report. Compare the three methods, if possible.

**Option 3:**

Select one project from the “projects” section at the end of each chapter. Use the method described in the project, and two additional mathematical modeling methods. Compare the three methods, if possible.

**Course project selection**

Any of the three options above are valid choices for your project.

**Project team**

Each team will consist of two members.

**Project schedule**

1. Form team by end of week 8 (October 18th, 11:59pm)
2. Project proposal draft by end of week 9 (<1 page, please address the problem that your team is trying to solve) (October 25th, worth 10% of project grade)
3. Discussion with the instructor to further improve the project proposal (week 10) (Nov 1st, 11:59pm)
4. Final project proposal by end of week 11 (<1 page) (Nov 8th, 11:59pm, worth 10% of project grade)
5. Project presentation slides due on Dec 10 8:00pm (Thursday)
6. Project presentation starts on Dec 10 8:15pm (Thursday, worth 30% of project grade together with project presentation slides submission)
7. Final project report (Dec 13th, 11:59pm, worth 50% of project grade)

**Project presentation**

The presentation shall be less than 15 minutes for each team. It will take place on Dec 10th 8:15pm through gotomeeting. Details will follow.

**Project report**

Feel free to explain the problems you are trying to solve in your project final report. It will be great if some of the following questions/issues will be addressed:

* Analysis of the problem.
* The methodology you used.
* Details of the methodology
* The findings from the project.
* Are they different from your initial expectation? If so, is there a suitable explanation?