Syllabus as of 8/16/2023. Please see Sakai for updates.

Modeling for Energy Systems Analysis Fall 2023 ENV/ENERGY 716L

Nicholas School of the Environment Duke University

Lectures
Tu-Th 8:30 – 9:45 am

Location
Field Auditorium – Grainger Hall

Lab sessions*

Lab 1, Fridays, 10:05 -11:20 am	Computer Lab 1104 - Grainger Hall
Lab 2, Fridays, 11:45 – 1:00 pm	Computer Lab 1104 - Grainger Hall
Lab 3, Fridays, 1:25 – 2:40 pm	Computer Lab 1104 - Grainger Hall

Instructor (lectures)
Dalia Patiño-Echeverri
Office hours: Fridays 2:45 – 4:00 pm at GH3118.

Instructor (lab sessions)
Dimitris Floros

Teaching Assistants and graders
Yasser Alabaishi, Grace Fernandez, Qiuying Liao, Jaimie Wargo

Office hours and other ways to get help:
If you have any questions regarding the course materials or assignments, please ask during the labs, during office hours, or post a question in the Sakai forum. You can also email 716ask@duke.edu, and one of us will reply. Office hours are in the common areas of Gross Hall unless otherwise announced at these times:

- Mondays: 5:30 - 7:30 pm – Grace – Zoom (https://zoom.us/j/98691325215?pwd=Qmt6S1ZLWVlTZ05EejdEZ1AxN2NsQT09)
- Tuesdays: 10:00 - 12:00 pm – Wendy – Grainger Hall
- Tuesdays: 12:00 - 2:00 pm – Yasser – Grainger Hall
- Wednesdays: 1:00 - 3:00 pm - Jaimie – Grainger Hall 1101
- Thursdays: 12:00 - 2:00 pm – Yasser –Grainger Hall
- Fridays:* 2:45 – 4:00 pm – Dalia – Grainger Hall 3100 except on 09/29 Grainger Hall 1100

*You can also ask Dimitris between lab sessions

Responsibilities of Teaching Assistants and Graders
-Grading the assignments and quizzes promptly
-Posting the solution to the assignments to SAKAI within 72 hours of the submission deadline
-Helping monitor the Sakai forum discussions and the messages to the 716ask@duke.edu
-Processing grading disputes
-Hosting office hours

*Students must attend lectures and labs in person (see attendance section). We plan to have one lecture (November 7) and two labs (September 8 and 15) on Zoom. Find the meeting information on Sakai's Zoom section or next to the corresponding dates in this syllabus. If there is inclement weather class will be on Zoom as well. We will notify you by 9 PM of the day prior.

Course Description

This course introduces computer programming, spreadsheet models, and optimization and simulation methods for students interested in analyzing energy systems. The course emphasizes formulating optimization problems and Montecarlo simulation models and their implementation and solution in Excel and Python.

We aim to enable students to formulate, implement, and use their quantitative models to support private and public decision-making affecting the global energy system and the environment. This course is a pre-requisite of ENVIRON/ENERGY 717 Markets for Electric Power, which examines basic concepts in **economics** and **engineering** necessary to understand the operation of electric power systems, with a focus on U.S. organized wholesale electricity markets.

Prerequisites

College-level calculus (including partial derivatives of functions of several variables), probability theory, and introductory linear algebra (how to write -and solve- systems of linear equations in matrix form). Students should also be familiar with capital-sigma ($\sum$) notation for compactly representing the summation of similar terms and be familiar with Excel.

Readings, videos, and other resources

As indicated in the class schedule below, readings are available online or via Duke Library and others via Sakai. Required readings begin with R.R. Optional readings begin with OR.

Additional resources for Excel and Python:

-The "Excel Bible" by John Walkenbach that corresponds to the version of Excel you will be using (i.e., Excel 2019, Excel 365, etc..) may be valuable for you. You may read it online from a Duke's library digital copy, but there is a limit on the number of concurrent viewers.

-The book "Python for Everybody: Exploring Data in Python 3" by Charles R. Severance and the companion resources available at https://www.py4e.com/ will be instrumental to complement and further clarify the content taught in lectures and labs. **The PDF of the book is free** on the website, but you can also buy a printed copy for less than $25.

-The book "Introduction to Computation and Programming Using Python, Second Edition With Application to Understanding Data" by John V. Guttag may be a good purchase if you want to continue your Python journey. You can also see the slides and video from the course taught by the book's author at https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-0001-introduction-to-computer-science-and-programming-in-python-fall-2016/2019/index.htm.

Sakai

Readings, class announcements, schedule changes, grades, PowerPoint slides, and working files will all be posted to the course Sakai site. Anyone having trouble working with the Sakai site should seek help from fellow students, T.A.s, or faculty or contact Information Technology (http://sakai.duke.edu/home.do). Please use the Sakai forum to discuss lectures, ask questions

about assignments, or share any resources or ideas you think may be helpful/interesting to others taking the course.

Software and computers

The labs and assignments will require computer programming and data analysis. For the lab sessions, you can either use your own laptop or one of the computers in GH 1104. The computer clusters on the third floor of GH and university libraries are also available for the assignments. We will use **Python** and **Google Colab** to develop our code. Google Colab is a tool that allows you to write, run and share Python codes within your browser without the need to install any software. Google Colab documents have extension "ipynb" (just like Jupyter notebooks) and use the Markdown format which means you can create a document that contains text, images, and executable code.

We will use **GitHub** to share the ipynb scripts developed in lectures and labs as well as some additional resources. GitHub is a cloud-based hosting service for software development where users can collaborate on and store their codes. Here is the link to the Github class repository. https://github.com/ENV716/Energy_Modeling_F2022. In depth instructions for using Colab and GitHub will be provided in the first lab session.

Course Assignments

Written assignments should be presented using Times Roman 12 pt font, single-spaced text, 1" margins. All assignments are to be submitted via Sakai. Problem sets can be hand-written and then scanned only if the text and math are written clearly and neatly. Points will be deducted for confusing or disorganized submissions.

There will be 12 assignments. The assignments ask to apply concepts and tools learned in class. Students are encouraged to work in study groups of up to three people on these problem sets and help each other learn. However, each student must submit his or her own copy of the assignment and it is a violation of the Nicholas School Honor Code to directly copy another student's work. It is also a violation of the Honor Code to exchange files with the complete or partial solution to assignment problems. An example of appropriate problem set collaboration would be for Student A to explain the procedure used in the problem to Student B. Then Student B goes off by himself and completes the problem again and writes up his own explanation. It would be inappropriate for Student B to directly copy the math, the code or the explanation/interpretation from Student A. Study groups are most effective when everyone attempts to do the problem sets BEFORE meeting as a group. Only those who really try to solve the problem on their own will realize whether they understand the methods and their application. Please write down the names of the students that worked with you in each assignment.

ChatGPT

This semester, we will discuss and utilize ChatGPT so that by the end of the course, you will possess a comprehensive grasp of its potential and constraints to make informed decisions about using AI technologies in your academic and professional life. ChatGPT is a versatile tool for various tasks, including data analysis, automating repetitive tasks, generating code in multiple programming languages based on high-level specifications, and crafting human-like text for

effective communication and documentation[1]. It can be a valuable addition to your toolbox, akin to search engines and Wikipedia, and can serve as a virtual assistant, boosting productivity and reducing the learning curve, particularly when tackling new programming languages.

Despite its benefits, it is crucial to approach ChatGPT with a critical eye and an awareness of the ethical considerations it entails. We will provide guidance on using this tool and encourage you to always disclose its use when presenting your work.

Assignment	Content covered	Posted Date	Due Date
1	Spreadsheet modeling and getting started with Python	09/1	09/9
2	Reading and analyzing excel data in Python	09/8	09/16
3	Conditionals, loops and functions in Python	09/15	09/23
4	Formulation and solution of linear programs I: graphic and excel solution. Data structures and	09/22	09/30
5	Formulation and solution of linear programs II: Sensitivity and post-optimality analysis.	9/29	10/7
6	Formulation and solution of linear programs III: Multi-period and network problems	10/6	10/21
7	Formulation and solution of linear programs IV: Mixed-integer problems and matrix notation	10/20	10/28
8	Multi-period LP and solving L.P. in Python	10/27	11/4
9	Review of Probability Theory	11/3	11/11
10	Probability Analysis – Monte Carlo Simulation I	11/10	11/18
11	Monte Carlo Simulation II (Excel and Python)	11/17	11/31
12	Monte Carlo Simulation III	12/1	12/12

Grading

Each assignment will be evaluated using a numbered grade (0-100) and your overall numbered grade will be determined using the following weights:

Assignments (12):	90%
Quizzes and class attendance and participation	10%
Total:	100%

[1] It is crucial to discern accurate statements from plausible-sounding yet erroneous responses. Unlike knowledge bases like Wikipedia, large language models like ChatGPT lack transparent sources or reasoning processes for their conclusions, occasionally conjuring non-existent references to support their arguments.

Letter grades of A+, A, A-, B+, B, B-, C+, C, C-, or F will be assigned according to numbered grades in the following way:

Above 100:	A+
(95-100]	A
(90-95]	A-
(85-90]	B+
(80-85]	B
(75-80]	B-
(70-75]	C+
(65-70]	C
(60-65]	C-
60 or below	F

Class attendance, participation, and quizzes.
Students must attend **in person** and participate actively during lectures and labs. During lectures we will track attendance and participation through **Poll everywhere**, asking questions about material covered in previous classes and assignments or about concepts just explained in class. Students can join the polls using the web/app or the sms system from a laptop, tablet, or phone. Please silence all your notifications and **use your electronic devices only for connecting to the polls**.
The lab sessions will always start with a SAKAI-based quiz. The response to these quizzes will be provided immediately after time so you can calculate your grade. We will **not** provide grades for quizzes. At the end of the semester, the quizzes grade will be calculated and compounded with a grade from attendance and participation. To get 100% on the grade for class attendance and participation, students must attend all lectures in person and participate actively and constructively for their own benefit and the benefit of others. There will not be any makeup quizzes or polls for **any reason (please do not ask), but the two worst quizzes (including missed quizzes) will be excluded from the calculation and will not affect** your final grade**.**

Policy on late assignments. All assignments are due by 11:55 pm on the posted due date. **Assignments submitted after the due date will lose 0.1 points per minute (for example, if you submit 180 minutes late, your maximum grade will be 72/100).**
Please review carefully all the files you submit on Sakai and resubmit if necessary. **We will not accept files submitted via email after the deadline**. **Please do not ask for exceptions**. Notice that for all assignments, you can resubmit up to three times. We only grade your last submission, and there is no penalty for resubmissions before the deadline. If you resubmit after the deadline, we will grade your most recent submission and apply the penalty for being late. If you are ill or have a family emergency that will prevent you from being able to complete the assignment on time, please submit the web-based short-term illness form *5 hours before* the due date. The short-term illness form can be found at: http://trinity.duke.edu/undergraduate/academic-policies/illness. You are governed by the Nicholas School Honor Code in completing this form (see below). Depending on your case, an assignment that is not submitted because of illness or family emergency will be excluded from your grade calculation (so the grade of the assignments will be based only on the assignments your submitted). If your illness or family situation prevents you from completing **more than one assignment**, please communicate this promptly.

We may recommend that you drop or withdraw from the class or require an oral or written test to evaluate your understanding of the material covered in the missed assignments.
An answer key for all assignments will be posted no later than 72 hours after the due date. Please take the time to review the answer key and identify any mistakes you may have in your assignment and any remaining questions you may have about the material.

Bonus points. Occasionally there will be opportunities for getting bonus points by attending and writing short commentaries on seminars, lectures, and extracurricular activities or by completing additional assignment problems. Some of you might be unable to participate, and that is ok. Because this class uses an absolute grading system (e.g., your grade is unaffected by the performance of your classmates), you should not feel it is unfair if time commitments prevent you from getting bonus points.

Grade disputes. Students will be informed of the grade received in each assignment no later than 12 days after the assignment has been submitted. Students who believe there has been a mistake in the grading process should upload to Sakai a written document no later than seven days after the grades have been released. Please do not talk to or send emails to the T.A.s regarding your grades. There will be a separate grade dispute folder for each assignment under the "Assignments" tab in Sakai.
The grade dispute document should contain the following information
1. The type of problem you found
a) a factual error (like adding up the numbers wrong or referencing something that is not there)
b) an inconsistency error (standards were inconsistently applied between students)
c) an interpretation dispute (you think you should have gotten more points)
2. A short description of the issue.
2a.Possibly including why you should get more points.
3. References that explain where to find the supporting material (e.g., "I put the graded document in your mailbox," or "My Excel model is in the digital Dropbox, and it is named *.xls"...).

The interpretation disputes may require faculty input and may only be resolved at the end of the semester. Other disputes will be resolved no more than three weeks after being submitted.

Although the grade dispute document needs to be uploaded no later than seven days after the graded assignments are returned, discrepancies occur when there is an error in adding up points for an assignment or when the wrong grade has been uploaded (i.e., points appearing in your 'Gradebook' on Sakai are different from points you received) have no expiration date. Let us know anytime (by email/in person during office hours) if you see such errors.

Nicholas School Honor Code and the Duke Community Standard

All activities of Nicholas School students, including those in this course, are governed by the Duke Community Standard, which states:

> "Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and nonacademic endeavors and to protect and promote a culture of integrity. To uphold the Duke Community Standard:

- I will not lie, cheat, or steal in my academic endeavors.
- I will conduct myself honorably in all my endeavors; and
- I will act if the Standard is compromised."

Please add the following affirmation to the end of all assignments and sign your name beside it: "*I have adhered to the Duke Community Standard in completing this assignment."*

Class etiquette and recommendations to succeed

1. Please give 100% of your attention to our class meetings. I recommend taking notes by hand (i.e., with pencil and paper instead of on your laptop) because research shows this helps students focus and learn[2]. Also, I ask you to do the following to minimize distractions:
   a) Keep your laptop, tablets, and cellphones away and in airplane mode (unless, of course, you need them to connect to the class polls or Zoom).
   b) If we are using the electronic polling system and need you to respond via connected devices, please modify the devices' settings to have "quiet hours" during the time of class. In this way, you will not receive any app notifications or announcements while you should be paying attention to class.

2. Please make sure you do everything you can to make our classroom culture a comfortable learning environment for everyone. We will likely have people from many different backgrounds in this class, and you should all feel and make each other comfortable while participating.

3. Please take responsibility for making the class successful. What you learn in the class will largely depend on your attitude and work. Ask yourself what you can do during each class to move the course forward positively.

4. If you must enter the class late, please do so quietly. I do prefer to have people joining late than skipping class.

Green Classroom Certification

"This course has achieved Duke's Green Classroom Certification. The certification indicates that the faculty member teaching this course has taken significant steps to green the delivery of this course. Your faculty member has completed a checklist indicating their common practices in areas of this course that have an environmental impact, such as paper and energy consumption. Some common practices implemented by faculty to reduce the environmental impact of their course include allowing electronic submission of assignments, providing online readings and turning off lights and electronics in the classroom when they are not in use. The eco-friendly aspects of course delivery may vary by faculty, by course and throughout the semester. For more

[2] See this note on NPR or see this article. You can also see the original research article: The Pen Is Mightier Than the Keyboard: Advantages of Longhand Over Laptop Note Taking
Pam A. Mueller, Daniel M. OppenheimerFirst Published April 23, 2014 https://doi.org/10.1177/0956797614524581

information on the Green Classroom Certification, visit: sustainability.duke.edu/action/classroom."

Social responsibility

Although our course does not directly discuss how to address the many social and cultural challenges that we must overcome to create a better world for all, we invite you to communicate with the instructors any ideas you may have to use the courses' content to enhance learning and reflection opportunities about our responsibilities and opportunities for action.

I hope the Land Acknowledgment presented below motivates us to use this course's concepts and tools to contribute to a just and kind energy transition. This land acknowledgment was written by Drs. Ryan Emanuel[3] and Malinda Lowery of the Lumbee Tribe.

Land acknowledgment

" What is now Durham was originally the territory of several Native nations, including Tutelo (TOO-tee-lo) and Saponi (suh-POE-nee) - speaking peoples. Many of their communities were displaced or killed through war, disease, and colonial expansion. Today, the Triangle is surrounded by contemporary Native nations, the descendants of Tutelo, Saponi, and other Indigenous peoples who survived early colonization. These nations include the Haliwa-Saponi (HALL-i-wa suh-POE-nee), Sappony (suh-POE-nee), and Occaneechi (oh-kuh-NEE-chee) Band of Saponi. North Carolina's Research Triangle is also home to a thriving urban Native American community that represents Native nations from across the United States. Together, these Indigenous nations and communities contribute to North Carolina's ranking as the state with the largest Native American population east of Oklahoma."

Class Topic and Readings Schedule

The required readings (R.R.) and optional readings (OR) are to be completed after each class. We will offer a friendly introduction to the readings topics in class and will expect you to further your knowledge by completing the R.R. shortly afterward.

1. **Tuesday, August 29 - Class Overview – introductions – why excel and Python**
   - OR-Excel 2016/2019 Bible: Chapters 1 through 4, review if needed
   - OR-Python for everyone Chapter 1

2. Thursday, August 31 - Spreadsheet modeling: A simple cost model

Good modeling practices. Form Controls.

- RR-EIA Levelized Cost of Electricity and Levelized Avoided Cost of Electricity Methodology Supplement.
- OR.- Rubin Ch 13 FinancialEng.pdf (Chapter on Economics and the Environment)
- OR-Excel 2016/2019 Bible: Chapter 10

[3] Dr.Ryan Emanuel is a NSOE faculty member and my office neighbor!

Lab 1 – More on Spreadsheet modeling and Python 101 | Google Colab & GitHub | Simple code - Dalia

- Python 101 - Installation step-by-step guide for Mac and P.C. users (available on Sakai)
- **Creating and saving new documents**
- OR-Python for everyone Chapter 2

3-4. September 5- September 7 – Exploration and analysis of data sets with Excel and Python. eGrid database.

Excel: If, count, countif, sum, sumif, indirect, tables, Pivot tables, Lookup, vlookup, data analysis (descriptive statistics, correlation, histograms)
Python: Pivot tables.

- RR- egrid_faq.pdf (eGRID FAQ: https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid-questions-and-answers)
- OR-Excel 2016/2019 Bible: Chapters 13, 14, 17, 33, 34. Review if needed

Lab 2 – Reading Excel files in Python | Data structures – on Zoom with Dimitris

- Import an Excel or CSV file into Python using Pandas
- Optional: Additional tutorials available at https://datatofish.com/python-tutorials/
- OR- -Excel 2016/2019 Bible: Chapter 42

5. Tuesday, September 12 – Introduction to Computer Programming in Excel and Python

Intro to VBA Excel Macros for Beginners.

- OR-Python for Everybody Chapter 3.

6. Thursday, September 14 – Defining functions in Python and execution and iteration

- Defining your own Python function, call and definition, argument passing, return data
- OR- Excel 2016/2019 Bible: Chapters 39-40. Review if needed.
- OR-Python for Everybody Chapter 4.

Lab 3 – Filtering data sets and Pivot Tables in Python – On Zoom with Dimitris

- **Filter data based on conditional statements;**
- Create Pivot tables in Python using Pandas
- **Save your filtered/pivot table as a new excel file.**
- Additional resource: https://realpython.com/defining-your-own-python-function/

7. Tuesday, September 19 – Computer Programming III

- If Then statements, Loops, Functions and Sub routines
- OR- Excel 2016/2019 Bible: Chapter 44
- OR-Python for Everybody Chapter 5.

8. Thursday, September 21 - Introduction to mathematical programming

Concepts: feasible region, feasible solution, objective function, decision variables, binding and non-binding constraints. Linear and non-linear programming. Assumptions of lp. Graphical method for lp problems with two decision variables

- OR-Energy modeling for policy studies.pdf (Hogan, W.W. (2002). Energy Modeling for Policy Studies. Operations Research, (50) 1, 2002, pp.89-95.)

- OR-Using graphical methods-LP.pdf (Reeb, J. and Leavengood (1998). Using graphical methods to solve linear programs.)

Lab 4: UDFs and dictionaries in Python | Basic Matrix Operations

- Defining your own Python function, call, and definition, argument passing, return data
- Addition, Subtraction, Multiplication, Transposition, and Inversion
- Python Numpy library
- RR-Vector and Matrix Algebra.pdf. pp1-10.(Excerpts from the books of Johnson &Wichern (Applied Multivariate Statistical Analysis)
- OR-using simplex methods LP.pdf (Reeb,J. and Leavengood (1998). Using the Simplex Method to Solve Linear Programming Maximization Problems.)

9. Tuesday, September 26 –L.P. post-optimality

10. Thursday, September 28 – L.P. sensitivity analysis – Formulation of L.P.s in different forms.

Formulating L.P. problems in canonical and standard form. Lp formulation using sigma-capital notation and in matrix form. Assumptions of lp. Example: Gasoline blending problem.

- OR-Bazaraa Ch-1.pdf. (Bazaraa M.S.; Jarvis, J.J.; Sherali, H.D. (1990) Linear Programming and Network Flows. Second Edition. New York: John Wiley & sons. Chapter 1: Introduction. pp1-24.)

Lab 5: Intro to L.P. optimization in Python | Install PYOMO library and CBC solver | Simple LP example

- Intro to the Pyomo library for modeling LP/MILP/NLP
- Solver integration, adjusting paths
- Simple examples: https://pyomo.readthedocs.io/en/stable/pyomo_overview/simple_examples.html

11. Tuesday, October 3 – Using the Gas blending problem to clarify the definition of feasible, infeasible, bounded, and unbounded L.P.s.

12. Thursday, October 5 - Network flow models problems. Transportation networks.

- OR-NetworkFlowModels_JensenBarnes.pdf (Jensen, P.A. & Barnes, J.W. (1980). Network Flow Programming. New York: John Wiley and Sons, Inc. Chapter 1: Network Flow Models. pp.1-50)

Lab 6: More on L.P. in Python and Excel

- Implementing LPs using numpy arrays
- Integrating dictionaries and UDFs in Pyomo
- Excel's Built-in Solver

13. Tuesday, October 10 - More on L.P. in Python | Sensitivity Analysis | Multi-period LP

- How to get dual variable and variable bounds in Pyomo

14. Thursday, October 12 - Network flow models problems. Transportation networks.

Expressing formulation in terms of vectors and matrices.

Lab 7: More on L.P. in Python | Multiperiod LPs

- **More examples of LPs in Python**
- **Using for loops to define constraint and objective functions**

OCTOBER 17 – NO CLASS – FALL BREAK

15. Thursday, October 19 - Networks: Trans-shipment
Expressing formulation in terms of vectors and matrices.

Lab 8: Network Models in Python

- **Implement instances of the transportation network problems**

16. Tuesday, October 24 - Networks: Shortest path

17. Thursday, October 26 - Networks: Maximum flow - Networks as an abstract representation of planning problems: Planning trucks replacement

- OR- Applications of Network Problems.pdf. M.O. Ball et al., Eds., Handbooks in OR & M.S., Vol. 7, Chapter 1 – *Applications of Network Optimization*. Ahuja, R.K. et al. 1995.

Lab 8: More on Network Models in Python

- **Implement instance of the shortest path and max flow**

17. Tuesday, October 31 – L.P. models for electricity industry decision making
If time allows: discussion of examples of optimal investment problems:

- RR-power planning ontario.pdf (Muller, R.A.&Geroge, P.J.(1985). *Northern Hydroelectric Development in and Optimal Expansion Program for Ontario Canada.* Canadian Public Policy-Analyse de Politiques, XI:3, pp.522-532)
- OR-Plugging ships in ports.pdf (Vaishnav, P et al. (2015). Shore Power for Vessels Calling at U.S. Ports: Benefits and Costs. Vaishnav, P, et al. Environmental Science and Technology 2015)

18. Thursday, November 2 – Review of Probability theory I

- OR- Basic concepts of probability theory.pdf Ross, S.M. (1998). A first course in probability. New Jersey: Prentice Hall. Chapter 4: Random variables. Sections 4.1-4.6. pp.126-144.
- OR-Ross, S.M. (2002) Simulation. San Diego: Academic Press.
  Chapter 2: Elements of probability. pp.5-36. (At least try to skim. Can skip section 2.7)

Lab 9: Review of Probability Theory II - generation of random variables in Excel and Python

- Library random in Python and random number generation

19. Tuesday, November 7 – Review of Probability Theory III – Class on Zoom: Dalia at the 40th USAEE/IAEE North American Conference (International Association for Energy Economics). Join from home or from the classroom.
https://duke.zoom.us
Zoom Meeting ID: 988 8287 1330
Passcode: Models23

20. Thursday, November 9 - Probability Analysis and Introduction to MonteCarlo simulation

- OR- Morgan and Henrion Chapters.pdf (Chapter 5 and an excerpt from Chapter 8 of Morgan and Henrion's book Uncertainty.)

Lab 10: Generating Random Variables in Python

- The *random* Module, drawing from different distributions, making results reproducible with rand.seed()

21. Tuesday, November 14 - MC: Fitting and generating random variables in Excel and Python (I)

- The *random* Module: drawing from different distributions; ensuring the replicability of results with rand.seed()

22. Thursday, November 16 - generating correlated random variables in Excel and Python (II)

Lab 11: More on Generating Random Variables in Python and Excel

- Drawing from joint distribution, drawing correlated random variables
- Graphs in Python with library matplotlib

23. Tuesday, November 21 – Simulating wind power
Thursday, November 23 – NO CLASS – THANKSGIVING BREAK
Markov Chain Monte Carlo Simulation

24. Tuesday, November 28 – Simulating wind Power II
Markov Chain Monte Carlo Simulation

- OR- MCMC for wind power simulation.pdf (Papaefthymiou et. al (2008). MCMC for Wind Power Simulation)
-

25. Thursday, November 30: Simulating wind Power III
More on Markov Chain Montecarlo

Lab 12: TBD