

EM384: Analytical Methods for Engineering Management Syllabus (AT 23-2)

	LSN	Date	LESSON NAME	Reading	Assignment	LESSON OBJECTIVES	COURSE OBJECTIVE
Modeling, Spreadsheet Engineering, and Data Analysis	01	11-Jan	Course Introduction and Ethics	Read Instructional Memorandum; Review course Teams Page & Syllabus Read INFORMS Ethics Guidelines.		Define a model and describe the different forms of models (Physical, Graphical, Mathematical). Understand the difference between the three types of analytics (Descriptive, Predictive, Prescriptive). Recognize the ethical considerations involved with gathering and analyzing data, using quantitative models, validating assumptions, and reporting results.	1) Understand the need for models and the role of spreadsheet modeling to provide analysis to support engineering management decisions. 5) Conduct sensitivity analysis on models and make recommendations to decision makers. 7) Recognize the ethical considerations involved with gathering and analyzing data, using quantitative models, validating assumptions, and reporting results.
	02	13-Jan	Modeling with Spreadsheets I	Read Lesson Handout "The Art of Modeling with Spreadsheets" Chapter 21.1 and 21.2	Homework Set 1 Assigned	Understand basic Excel skills for good model development, such as creating efficient and logical layouts. Understand and apply relative and absolute cell referencing in Excel. Understand and apply basic Excel formulas (SUM, AVG, STD), value formatting, cell formatting, and row/column manipulation.	
	03	18-Jan	Modeling with Spreadsheets II	Read Lesson Handout "The Art of Modeling with Spreadsheets" Chapter 21.3 and 21.4 Watch NPV Video		Understand and apply Net Present Value (NPV) to a problem. Execute advanced Excel commands (COUNT, IF, nested IF, SUMPRODUCT, NPV). Apply conditional formatting to a spreadsheet.	
	04	20-Jan	Sensitivity Analysis Using Spreadsheets II	Read Lesson Handout "Analysis Using Spreadsheets" Chapter 4.1-4.3		Understand 'Base Case' and 'What-If' analysis and apply using spreadsheet models. Apply 1-way and 2-way data tables to a problem.	
	05	23-Jan	Sensitivity Analysis using Spreadsheets II	Read Lesson Handout "Analysis Using Spreadsheets" Chapter 4.5	Homework Set 1 Due Homework Set 2 Assigned	Understand 'Breakeven' analysis and apply using spreadsheet models. Apply 'Goal-Seek' to a problem.	
	06	26-Jan	Data Exploration and Analysis I	Read Lesson Handout "Data Exploration and Analysis" Watch YouTube Video on Pivot Tables Complete PivotTable Tutorial. Install Anaconda Navigator and Spyder using the video instructions.		Define a database and describe its components. Use the five-step process for data exploration to evaluate a database. Generate conclusions from examining relationships among variables. Create a 'Pivot Table' in Excel from a dataset.	
	07	30-Jan	Data Exploration and Analysis II	Watch tutorial video on Python libraries, data structures and control structures.	Quiz #1 (20 points)	Understand the use of Python libraries. Understand basic Python data structures (integer, float, boolean, string, and lists/Numpy arrays), including assignment of values and referencing. Understand basic Python control structures (IF, ELSE, FOR).	
	08	1-Feb	Data Exploration and Analysis III	Watch tutorial video on Python Pandas.		Understand the Python Pandas DataFrame data structure. Generate a DataFrame from a CSV file. Generate summary statistics for data in Python (Mean, Median, Mode). Filter a Pandas dataFrame using [] and conditionals	
Optimization Models: Linear Programs	09	3-Feb	Introduction to Linear Programs	Read Chapter 3.1 (pages 32-35, stop at Graphical Solution)	Homework Set 2 Due Homework Set 3 Assigned	Understand the characteristics of linear programming as a subset of optimization. Formulate a linear program algebraically. Identify the three parts to a linear program: Objective Function, Decision Variables, and Constraints	1) Understand the need for models and the role of spreadsheet modeling to provide analysis to support engineering management decisions. 2) Given a scenario description, recognize problems that can be modeled using linear programming. Build and analyze an appropriate model. 5) Conduct sensitivity analysis on models and make recommendations to decision makers. 6) Communicate in written reports and electronic media the modeling process, results, and recommendations.
	10	6-Feb	Solving Linear Programs using a graphical method I	Read Chapter 3 (Pages 35-end of 3.2)		Solve a linear program with two decision variables graphically by enumerating extreme points or using level curves. Understand and apply the following terminology for Linear Programs: Feasible region, Infeasible region, Feasible solution, Infeasible solution, Optimal solution, Boundary, Extreme Points.	
	11	9-Feb	Solving Linear Programs using a graphical method II	Review Chapter 3.3	Homework Set 3 Due Homework Set 4 Assigned	Understand and be able to define the four assumptions of linear programming: Proportionality, Additivity, Divisibility, and Certainty	
	12	13-Feb	WPR 1	Review Lessons 1-11	WPR 1 (150 points)		
	13	16-Feb	Resource Allocation Problems	Read Chapter 3.5 Install Excel Solver using the video instructions		Understand and recognize resource allocation problems. Formulate resource allocation problems algebraically. Solve linear resource allocation problems using Excel Solver.	
	14	22-Feb	Cost-Benefit Trade-off Problems	Read Chapter 3.4 (Stop at Distribution Unlimited on page 59)		Understand and recognize cost-benefit trade-off problems. Formulate cost-benefit trade-off problems algebraically. Solve cost-benefit trade-off problems using Excel Solver.	
	15	24-Feb	Mixed problems	Review Chapter 3.5	Homework Set 4 Due Homework Set 5 Assigned	Understand and recognize mixed problems. Formulate mixed problems algebraically. Solve mixed problems using Excel Solver.	
	16	27-Feb	Sensitivity Analysis II	Read Chapter 7.3		Create and interpret Sensitivity Reports, to include: Shadow Price Reduced Cost Constraint outcomes: binding and nonbinding.	
	17	1-Mar	Sensitivity Analysis II	Review Chapter 7.3		Create and interpret Sensitivity Reports, to include: Shadow Price Reduced Cost Constraint outcomes: binding and nonbinding.	
	18	3-Mar	Introduction to Linear Programs in Python	Watch tutorial video on Python PuLP.	Homework Set 5 Due	Model and solve a linear program in Python using the PuLP Library, and interpret the results to include the sensitivity analysis.	
SPRING BREAK							

	LSN	Date	LESSON NAME	Reading	Assignment	LESSON OBJECTIVES	COURSE OBJECTIVE
Network Optimization	19	13-Mar	Introduction to Minimum Cost Network Flow Problems	Read 10.1 - 10.2	Homework Set 6 Assigned	Understand network flow problems as a subset of linear programming problems. Define a network flow problem and identify where it may be applicable. Understand minimum cost flow network flow problems. <u>Generate a diagram for a minimum cost network flow problem.</u>	1) Understand the need for models and the role of spreadsheet modeling to provide analysis to support engineering management decisions. 3) Given a scenario description, recognize problems that can be modeled using network and integer programming models. Build and analyze an appropriate model. 5) Conduct sensitivity analysis on models and make recommendations to decision makers. 6) Communicate in written reports and electronic media the modeling process, results, and recommendations.
	20	15-Mar	Transportation Problems	Read Chapter 9.1		Recognize a transportation problem given a network problem. Formulate and solve a transportation problem in Excel Solver. Interpret the reduced costs for a transportation problem solution.	
	21	17-Mar	Assignment Problems	Read Chapter 9.3		Recognize an assignment problem given a network problem. Formulate and solve an assignment problem in Excel Solver. Interpret the reduced costs for an assignment problem solution.	
	22	20-Mar	Transshipment Problem I	Read Chapter 23.1 in PDF	Homework Set 6 Due Homework Set 7 Assigned	Recognize a transshipment problem given a network problem. Formulate and solve a transshipment problem in Excel Solver. Interpret the reduced costs for a transshipment problem solution.	
	23	23-Mar	Transshipment Problem II	Read Chapter 10.6 (Stop at Shortest path problems on page 389)	Quiz #2 (20 points)	Recognize a transshipment problem given a network problem. Formulate and solve a transshipment problem in Excel Solver. Interpret the reduced costs for a transshipment problem solution.	
	24	27-Mar	Binary Decision Variables	Read Chapter 12.1		Understand Integer Programming as a subset of optimization problems. Describe how binary decision variables are used to represent yes-or-no decisions. Explain the difficulties with models requiring binary/integer variables. <u>Use binary decision variables and logical relationships in integer programming.</u>	
	25	29-Mar	Site Selection Problems I	Read Chapter 12.2 - 12.3		Recognize a site selection problem given a transportation problem. Formulate and solve in Excel a site selection problem using binary decision variables. Interpret the reduced costs for a site selection problem solution.	
	26	31-Mar	Site Selection Problems II	Review Chapter 12.2 - 12.3	Homework Set 7 Due	Recognize a site selection problem given a transportation problem. Formulate and solve in Excel a site selection problem using binary decision variables. Interpret the reduced costs for a site selection problem solution.	
	27	3-Apr	WPR 2	Review Lessons 12-26	WPR 2 (150 points)		
Monte Carlo Simulation	28	6-Apr	Random Variables and Probability Distributions I	Read Chapter 20.1	Homework Set 8 Assigned	Understand the concept of a stochastic model. Understand random variables and their role in simulation. Apply randomness to Excel models. <u>Execute Excel commands RAND, RANDBETWEEN</u>	1) Understand the need for models and the role of spreadsheet modeling to provide analysis to support engineering management decisions. 4) Given a brief scenario description, recognize problems that can be modeled using simulation. Build and analyze an appropriate model using a software programming language. 6) Communicate in written reports and electronic media the modeling process, results, and recommendations.
	29	10-Apr	Random Variables and Probability Distributions II	Read PDF Handout on Random Variables and Probability Distributions part 1		Describe the characteristics of three discrete probability distributions that can be incorporated into a simulation (Bernoulli, Binomial, Poisson) using the PMF and CDF Recognize the shape of three discrete probability distributions (Bernoulli, Binomial, Poisson). <u>Derive the probability of events by using the PMF and CDF.</u>	
	30	12-Apr	Random Variables and Probability Distributions III	Read PDF Handout on Random Variables and Probability Distributions part 2		Describe the characteristics of three continuous probability distributions that can be incorporated into a simulation (Normal, Uniform, Exponential). Recognize the shape of three continuous probability distributions (Uniform, Normal, Exponential). <u>Derive the probability of events by using the PDF and CDF.</u>	
	31	14-Apr	Monte Carlo Simulation Applications in Excel I	Read Chapter 24.5 - 24.6 PDF		Understand Monte Carlo simulation. Use Excel to simulate random variables. Create a Monte Carlo simulation in Excel. <u>Interpret the results of a Monte Carlo Simulation.</u>	
	32	17-Apr	Monte Carlo Simulation Applications in Excel II	Review Chapter 24.5 - 24.6 PDF	Homework Set 8 Due Homework Set 9 Assigned	Understand Monte Carlo simulation. Use Excel to simulate random variables Create a Monte Carlo simulation in Excel. <u>Interpret the results of a Monte Carlo Simulation.</u>	
	33	20-Apr	Simulating Random Variables in Python	Watch tutorial video on simulating random variables in Python. Read accompanying handout.	Quiz #3 (20 points)	Use the Numpy and/or Scipy.stats libraries to simulate random variables for three discrete probability distributions in Python (Bernoulli, Binomial, Poisson, Uniform, Normal, Exponential). Visualize the results of a simulation using a histogram in Python. Visualize the results of a simulation using an empirical cumulative distribution function (ECDF) in Python.	
	34	24-Apr	Monte Carlo Simulation Applications in Python I	Read Monte Carlo Simulation with Python PDF		Design and implement simple Monte Carlo simulations in python. Visualize the results of monte carlo simulation in python. Create and interpret an empirical cumulative distribution function (ECDF) from the results of the model.	
	35	26-Apr	Simulation Control Structures in Python	Watch tutorial video on using simulation control structures in Python. Read accompanying handout.	Homework Set 9 Due Homework Set 10 Assigned	Use control structures to implement simulation logic in Python (IF (ELIF, ELSE), FOR, and WHILE)	
	36	1-May	WPR 3	Review Lessons 28-35	WPR 3 (150 points)		
	37	5-May	Monte Carlo Simulation Applications in Python II	Review Monte Carlo Simulation with Python PDF		Design and implement Monte Carlo simulation that requires control structures Devise and implement key performance indicators that describe the model.	
	38	8-May	Monte Carlo Simulation Applications in Python III	Review Monte Carlo Simulation with Python PDF		Design and implement Monte Carlo simulation that requires control structures Devise and implement key performance indicators that describe the model.	
	39	10-May	Monte Carlo Simulation Applications in Python IV	Review Monte Carlo Simulation with Python PDF	Homework Set 10 Due	Design and implement Monte Carlo simulation that requires control structures Devise and implement key performance indicators that describe the model.	
	40	11-May	Course Review	Review Lessons 1-40	TEE Prep	Assess EM384 and your ability to execute the seven course objectives.	