FOSTER SCHOOL OF BUSINESS
UNIVERSITY OF WASHINGTON

Modeling with Spreadsheets
QMETH 551
Winter 2021

Instructor
Mark Hillier
Office Hours: Wednesdays 5:00–6:30pm on Zoom (link)
e-mail: mhillier@uw.edu
Canvas Portal: https://canvas.uw.edu/courses/1435993
Feel free to stop by office hours on Zoom for individual help (no appointment necessary), or email outside of office hours with questions.

Teaching Assistant
Yiming Zhang
Office Hours: by appointment (available 7–10am and after 5pm only due to time zone—Yiming is doing a project in China during Winter quarter)
e-mail: ym227@uw.edu
Yiming (a doctoral student at Foster) is an additional resource for help with the class. Feel free to email questions and/or set up a Zoom meeting for individual help with the class or problem sets.

Course Description
This course covers modeling with spreadsheets for analyzing quantitative aspects of business problems. Spreadsheets now have features that allow managers to perform sophisticated quantitative analysis in the comfortable and intuitive environment of the spreadsheet. This gives managers the power of quantitative analysis tools without forcing them to use unfamiliar mathematical notation. Applications from a variety of business areas will be discussed, including finance, marketing, and operations. Sample applications include cash flow problems, portfolio optimization, pricing models and revenue management, municipal bond underwriting, project management, supply chain management, facility location, shortest path and routing, equipment replacement, advertising media selection, and budget-constrained project selection.

Required Materials
Hillier and Hillier, *Introduction to Management Science*, 5th or 6th Edition, McGraw-Hill/Irwin.
Course Packet includes class slides, problem sets, and case studies. Available in paper form from E Z Copy N' Print at 4336 University Way (or electronically on Canvas).

Course Packet
I have prepared extensive course notes that I use as slides during class. These course notes include examples that we will work together in class and other lecture material. The course notes are not intended as material that you use to prepare for class; my intent is for them to make it easier for you to listen, ask questions, and participate in class, rather than take lots of your own notes during the lectures.

Software

Microsoft Excel (including Solver), Solver Table (available on Canvas), and Crystal Ball (see instructions on Canvas). For Windows, Excel 2010 and later will work for this course. For the Mac, Excel's Solver is somewhat unreliable so a Windows version of Excel should ideally be used—please read the page on Canvas for Mac Users (available on the Home Page). Excel for Windows and Crystal Ball are also available through computers in the Paccar Computer Lab (Paccar 191), including virtually through a browser (Mac or Windows). Instructions for this are available on the Canvas Home Page.

Delivery Method

Due to the pandemic, this class will be offered remotely. For most class sessions, there is some material that is best delivered asynchronously (through videos that I will be recording for you)—basically lecture material. Then there is other material that is more interactive (involving more discussion) that is best delivered synchronously, in a live class meeting over Zoom.

Therefore, I will be dividing up most class sessions as follows:

> **Before Class:** There will typically be a video or a set of videos to watch (posted on Canvas) that must be watched *before* the live class session. The live class session will assume that *everyone* has watched these videos. (For the evening section, where two class sessions are combined in one evening, note that there may be two sets of pre-class videos to watch.) A discussion board will be provided for each video, so you can post any questions or comments you may have. Please monitor these discussion boards. If you have a question, be sure it hasn't already been asked (and possibly answered) to avoid cluttering the board with repetition. If you have an answer to another student's question, please provide it—I strongly encourage you to help out your fellow students. Yiming and I will also be monitoring the discussion boards periodically to offer my help and answer questions.
>
> **Live Class Session:** On scheduled class days, you will join a Zoom meeting at 10:30am for the daytime section (link), and at 6:00pm for the evening section (link). You should join with video *on* and audio *muted*.
>
> **After Class:** There may be a video or a set of videos to watch (posted on Canvas) that should be watched *after* the live class session. As with the before-class videos, a discussion board will be provided for you to post questions, comments, and answers, that Yiming and I will also be monitoring.

I expect that the cumulative time of the recorded videos and the live class sessions will be roughly the same amount of time that was traditionally allocated for the class session when offered in person. As appropriate for the material being covered, some sessions will have many recorded videos and just a shorter live-class session; others will have few recorded videos and a longer live class session. The live classes will always start at the designated start time (10:30am or 6:00pm), but often end before the scheduled ending time.

Academic Integrity

By being a student in this course you acknowledge that you are a part of a learning community at the Foster School of Business that is committed to the highest academic standards. As a part of this community, you pledge to uphold the fundamental standards of honesty, respect, and integrity, and accept the responsibility to encourage others to adhere to these standards. Furthermore, as part of the Foster MBA program, we have jointly agreed to conform to and uphold the MBA Honor Code.

Grading Policy

The course grade will be based on problem sets, two exams, a student presentation, and class participation, with the following weights:

- Problem Sets (individual) 10%
- Problem Sets (team) 20%
- Midterm Exam 25%
- Final Exam 25%
- Student Project and Presentation 15%
- Class Participation 5%

Problem Sets

Five graded problem sets will be assigned in order to provide you the opportunity to develop and apply the concepts and tools discussed in class. Modeling with spreadsheets is best learned by doing. Therefore it is critical that every student first attempt to set up and solve each of the problems in the problem set on their own. It is fine (even encouraged) to discuss and/or get help from classmates at this point, whether in person or virtually. Any help provided should be via discussion only (including sharing screenshots to aid the discussion if needed), but should *not* include sending or copying of files or portion of files. Everything in your individual submission should be entered by you, based on your understanding of the material. This individual attempt should be submitted to Canvas. The individual submissions will be reviewed, but only graded for completion and effort with feedback given only if there was a deficiency in completion or effort. Students should then meet in their pre-assigned study teams (virtually as needed) to compare solutions, clarify issues that were encountered, and streamline the various analyses into a single submission from the team. Take this opportunity to make sure everyone on the team understands the material and everything in the team assignment that is being submitted. At this stage (after everyone has submitted their individual submissions), sharing of files is permitted. One member of each team should submit the team submission to Canvas. If possible, include all spreadsheets in a single workbook on separate tabs. The team submissions will be graded for accuracy and correctness, and thorough feedback provided.

Study Teams

The problem sets and student projects will be done in teams of three to five. The problem set teams will be self-selected on the first day of class. The teams for the projects can be chosen later. It is acceptable (and typical) that the student project teams be the same as the problem set teams, but this is not required. At the end of the quarter, each member of the team will also evaluate each of the other members of the team in terms of their percentage contribution to the team's problem sets and/or student project and presentation. The individual evaluations will be confidential, made directly to me through Canvas. Your evaluations from others in your team will be combined and evaluated and individuals that did not make a fair contribution (or made extraordinary contributions) to the team will have their overall problem set or project scores adjusted accordingly.

Exams

The midterm exam and final exam will both be take-home exams. You will be given nearly one week for each. These exams are open book and open notes with no time limit (other than the due date), but must be completed individually, without assistance from any other person. Use of the internet (beyond the class Canvas site) is not allowed.

Student Projects & Presentations

Student projects and presentations will be done in teams of three to five students. You may stay in the same teams as for the problem sets (typical), but this is not required. Presentations will be given at the end of the quarter on two dates during our live class sessions on Zoom. If you have a preference for presentation day, please let me know ASAP. I will accommodate as best as possible on a first-come-first-served basis.

You may choose either of the following for the topic of your presentation:

1. Develop a spreadsheet model that addresses a decision that needs to be made. Present the decision to be made, the spreadsheet model developed to address it, and the results of the model.

2. Research a model that was developed by a business to address a decision that needed to be made. There are many references to "real-world" applications in the textbook. Most make reference to the journal *Interfaces* (available in the Foster library, including virtually through links available on Canvas), which is a good resource for management science models that have been developed and used in business. Present a "case study" of the model, including discussion of the decision to be made, demonstrating a spreadsheet version of the model that was developed, and discussing the results obtained with the model. The model need not have originally been a spreadsheet model (e.g., it may have been an LP solved using an algebraic solver); if it is not, you will need to create a spreadsheet based upon the ideas of their model to show the class how the model works in spreadsheet form.

In either case, the spreadsheet model should build upon or be related to one of the techniques covered in this class. The presentations should be approximately 10 minutes after which there will be a short question-and-answer period. The presentation (and spreadsheet submission) will be graded for both content (two-thirds weight) and quality of presentation (one-third weight). Qualities I will be looking for include: (1) does the model build effectively on the modeling techniques discussed in class, (2) how well does the model address the decision being made, (3) is the presentation clear and easy to understand, (4) can you convince the audience that the model is effective and the solution a good one. More successful presentations typically discuss the model at a relatively high level, without digging into the model at the formula level.

Deliverables:

- Thursday, February 18 (by the end of the day), please email me (mhillier@uw.edu) a list of your team members, a brief description of your topic, a brief description of the model you intend to build or discuss, and a date preference (if you have one) for the presentation.

- At least one hour before class on your presentation day, please have one member of your team submit to Canvas the spreadsheet model that your team has built and any other electronic items used in your presentation (e.g., Powerpoint slides).

Class Participation

Class participation is important. The class should be a common learning experience. Thus, we want you to take ownership and initiative for the success of the class. It is critical that you arrive for each class fully prepared to lead the discussion if called upon. Share your knowledge and help others understand your point of view.

To assure that everyone gets a chance to participate, I will be utilizing a "warm-call" list. At the start of class, I will post a list of several students (chosen randomly). During class, I will periodically pose questions, and will call upon the students from this list (in order). I have found that this helps draw out participation from quieter students and also helps the discussion to not be dominated by just a vocal few, all with less anxiety than "cold calling".

Religious Observance Accommodation

Washington state law requires that UW develop a policy for accommodation of student absences or significant hardship due to reasons of faith or conscience, or for organized religious activities. The UW's policy, including more information about how to request an accommodation, is available at Religious Accommodations Policy (https://registrar.washington.edu/staffandfaculty/religious-accommodations-policy/). Accommodations must be requested within the first two weeks of this course using the Religious Accommodations Request form (https://registrar.washington.edu/students/religious-accommodations-request/).

QMETH 551 Schedule

	Day Section (A&B)	Eve Section (C&D)
Session #1: Modeling with Spreadsheets **Review:** Text, Chapter 1	Mon, January 4	Mon, January 4
Session #2: Applications of Linear Programming **Review:** Core Sessions #2-4; Text, Chapters 2-4	Wed, January 6	
Due: Problem Set #1 (Linear Programming)	**Sun Jan 10 (individual)/Mon Jan 11 (team)**	
Session #3: Network Models **Read:** Text, Chapter 6	Mon, January 11	Mon, January 11
Session #4 Nonlinear & Separable Programming **Read:** Text, Sections 8.1–8.3	Wed, January 13	
Session #5 Applications of Optimization	asynchronous class (view recordings)	
Due: Problem Set #2 (Network & Nonlinear)	**Sun Jan 24 (individual)/Mon Jan 25 (team)**	
Session #6: Applications of Integer Models **Review:** Core Session #6; Text, Chapter 7	Mon, January 25	Mon, January 25
Session #7: Municipal Bond Underwriting Case Study **Prepare:** Municipal Bond Case Study (available on Canvas)	Wed, January 27	
Due: Problem Set #3 (Integer)	**Sun Jan 31 (individual)/Mon Feb 1 (team)**	
Session #8: Multiple Objectives and Goal Programming **Read:** Text, Chapter 17	Mon, February 1	Mon, February 1
Session #9: Evolutionary Solver **Read:** Text, Sections 8.4–8.5	Mon, February 8	
Due: Midterm Exam (Available Monday, February 1, 10pm)	**Sunday, February 7**	
Session #10: Macros, VBA, Analytic Solver, and alldifferent Constraint	Wed, February 10	Mon, February 8
Session #11: Simulation and Crystal Ball **Review:** Core Sessions #9-10; Text, Sections 20.1–20.8	Wed, February 17	
Due: Problem Set #4 (Goal, Evolutionary)	**Tue Feb 16 (individual)/Wed Feb 17(team)**	
Due: Student Project Proposals	**Thursday, February 18**	
Session #12: Mountain Realty Case Study **Prepare:** Mountain Realty Case Study (available on Canvas)	Mon, February 22	Mon, February 22
Session #13: Optimizing with Simulation **Read:** Text, Section 20.9	Wed, February 24	
Due: Problem Set #5 (Simulation)	**Sun Feb 28(individual)/Mon Mar 1(team) [or Sun Mar 7(ind)/Mon Mar 8 (team) if team presenting March 1 or 3]**	
Session #14: Models for Analyzing Waiting Lines **Read:** Text, Sections 11.1–11.7	Mon, March 1	Mon, March 1
Session #15: Student Project Presentations	Wed, March 3	
Session #16: Analysis of Waiting Lines **Read:** Text, Sections 11.8–11.9	Mon, March 8	Mon, March 8
Session #17: Student Project Presentations	Wed, March 10	
Due: Peer Evaluations	**Thursday, March 11**	
Due: Final Exam (Available Monday, March 8, 10pm)	**Sunday, March 14**	

all deliverables due by the end of the day (11:59pm) on the date indicated

Session Summaries

Session #1: Modeling with Spreadsheets

In this session we will discuss the role of models in managerial decision making, including the use of spreadsheets, and provide an overview of the models and techniques to be covered in this quarter. We discuss good and poor spreadsheet modeling, and how proper layout and formatting can produce models that are easier to build, debug, read, and modify.

Session #2: Applications of Linear Programming with Spreadsheets

We discuss applications of linear programming with spreadsheets to problems in finance, marketing, and operations.

Session #3: Network Models

Transportation and communication networks pervade our daily lives. In this session, we discuss applications of network optimization. We then discover that most network optimization problems are really linear programming problems. We discuss minimum-cost flow, maximum flow, shortest path, and equipment replacement problems.

Session #4: Nonlinear and Separable Programming

Here we discuss spreadsheet models with a nonlinear objective function and/or nonlinear constraints. What are the ramifications on solvability? We also will discuss the use of separable programming to approximate a nonlinear model with a linear one.

Session #5: Applications of Optimization

In this session we combine various optimization techniques to develop advanced optimization models addressing problems in project management and pricing and revenue management.

Session #6: Applications of Integer Models

In this session we address problems where some or all of the decision variables are required to assume integer values and discuss the application of binary variables. We review big-number constraints and also add to the "bag of tricks" that are possible with binary variables.

Session #7: Municipal Bond Underwriting Case Study

In this session we discuss the application of binary integer models to a municipal bond underwriting case. We also discuss other advanced applications of integer programming.

Session #8: Multiple Objectives and Goal Programming

In this session we look at problems that have more than one objective. Techniques for addressing all of the objectives are discussed.

Session #9: Evolutionary Solver

We introduce genetic algorithms and the Evolutionary Solver to address problems that can not be solved using the standard Solver.

Session #10: Macros, VBA, Analytic Solver, and the AllDifferent Constraint

In this session we will discuss the use of macros and VBA, how they can aid in modeling, and how they can be used to create a decision support system. Next, the Analytic Solver Platform will be demonstrated. Finally, we discuss the alldifferent constraint and its applications.

Session #11: Simulation and Crystal Ball

In this session we discuss the use of the Crystal Ball Excel add-in for performing Monte-Carlo simulation, and applications in finance, marketing, and operations.

Session #12: Mountain Realty Case Study

In this session we will use Crystal Ball to explore a business decision faced by Mountain Realty.

Session #13: Optimizing with Simulation

In this session we discuss how optimization can be performed with a simulation spreadsheet model. The OptQuest add-in for Crystal Ball will be demonstrated.

Session #14: Models for Analyzing Waiting Lines

In this session we introduce analytical models and corresponding spreadsheet templates for predicting the effects of congestion in waiting line systems. Single and multiple-server queues, priority queues, and systems with finite queue capacity will all be discussed.

Session #15: Student Presentations

Groups of three to five students will give a 10 minute presentation about a model that they have developed or that a business has used to analyze a problem.

Session #16: Analysis of Waiting Lines

In this session, we utilize the queueing templates to make the following kinds of decisions: How many servers should we use? How much space needs to be made available for the waiting line? How many phone lines and representatives should a call center utilize? When should a priority scheme be utilized?

Session #17: Student Presentations

Groups of three to five students will give a 10 minute presentation about a model that they have developed or that a business has used to analyze a problem.