

# 550.400: Mathematical Modeling and Consulting

## Lecture Notes

**Instructor:**

Dr. N. H. Lee

JHU AMS 2012 FALL

Last Compiled on September 19, 2012

# Outline

## Lesson Plan

## Textbook

Writing about Numbers  
Math. Modeling

## Project

Work Statement  
Glossary

# Today's Lesson Plan

1. Share Your Favorites: WMA Chapter 2
2. Share Your Favorites: IMM Chapter 1
3. Work Statement Example
4. Is Tennis Fair?
5. How to sync two git local folders

# Resume HW

## Common Problems:

- 1 page only means 1 page only
- Use the template! mean use the template
- Typos; .edu  $\neq$  .eud
- No need for GPA
- No facebook link
- Use a darker color

# Work Statement

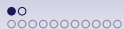
## Work Statement Examples

See *Protein Pathways* Project Work Statement

# Is Tennis Fair?

Review of our work done last time.

- What is tennis (for our mathematical modeling purpose)?
- What was assumed to be ignored?
- How was the server's advantage modeled?
- What did we do to simplify our model?
- Is there a “generalized” rule that models the tennis set winning determination?
- Who could be your sponsor/client? (Try USTA)



# Outline

Lesson Plan

Textbook

Writing about Numbers

Math. Modeling

Project

Work Statement

Glossary

# Seven Basic Principles

1. Set the context
2. Choose effective examples and analogies
3. Choose vocabulary to suit your readers
4. Decide whether to present #s in text, tables, or figures
5. Report and interpret #s in the text
6. Specify the direction *and* size of an association between variables
7. For many #s, summarize overall pattern



# Outline

Lesson Plan

Textbook

Writing about Numbers  
Math. Modeling

Project

Work Statement  
Glossary

## Models and Reality: “Disclaimer”

*Here we are concerned exclusively with mathematical models, that is, models that mimic reality by using the language of mathematics. Whenever we use “model” without a modifier, we mean “mathematical model.”*

# Models and Reality

*What makes Mathematical models useful? If we “speak in mathematics,”*

- *We must formulate our ideas precisely and so are less likely to let implicit assumptions slip by,*
- *We have a concise “language” which encourages manipulation,*
- *We have a large number of potential theorems available,*
- *We have high speed computers available for carrying out calculations.*

## Properties of Models

*A mathematical model is an abstract, simplified, mathematical construct related to a part of reality and created for a particular purpose.*

*Since a dozen different people are likely to come up with a dozen different definitions, don't take this one too seriously;*

*rather, think of it as a crude starting point around which to build your own understanding of mathematical modeling.*

# Properties of Models

*As far as a model is concerned, the world can be divided into three parts:*

- 1. Things whose effects are neglected,*
- 2. Things that affect the model but whose behavior the model is not designed to study,*
- 3. Things the model is designed to study the behavior of.*

## Building a Model: “Disclaimer”

*Model building involves imagination and skill. Giving rules for doing it is like listing rules for being an artist; at best this provides a framework around which to build skills and develop imagination.*

*It may be impossible to teach imagination. I won't try, but I hope this book provides an opportunity for your skills and imagination to grow. With these warnings, I present an outline of the modeling process.*

# Building a Model

*With these warnings, I present an outline of the modeling process.*

1. *Formulate a problem*
2. *Outline the model*
3. *Is it Useful?*
3. *Test the model*

## Building a Model

*Some models may require no data. If a model makes the same prediction regardless of the data, we are not getting something for nothing because this prediction is based on the assumptions of the model.*

*To some extent, the distinction between data and assumptions is artificial. In an extreme case, a model may be so specialized that its data are all built into the assumptions.*



## Building a Model

*The manager of a large commercial printing company asks your advice on how many salespeople to employ.*

*Qualitatively, more salespeople will increase sales overhead, while fewer salespeople may mean losing potential customers.*

*Thus there should be some optimum number.*

## IMM Problem: “Disclaimer”

*Some of the problems in this book lead you step by step through the development of a model and thus resemble the mathematics problems you have seen in other courses;*

*however, many problems are closer to real life: They are vaguely stated, have multiple answers (models), or are open ended.*

*I strongly recommend working in small groups on the problems to bring out various ideas and evaluate them critically.*

# Models and Reality

*The ultimate test of a model is how well it performs when it is applied to the problem it was designed to handle.*

*A model is used, it may lead to incorrect predictions. The model is often modified, frequently discarded, and sometimes used anyway because it is better than nothing. This is the way science develops.*

# Outline

## Lesson Plan

## Textbook

Writing about Numbers  
Math. Modeling

## Project

Work Statement  
Glossary

## Mission Impossible?: an analogy

Mission Impossible Season 2 Episode (00:00 – 06:25)



# Project in Industry: Frequently Recurring Elements

A stylized timeline:

1. Work Statement,
2. Midterm Presentation,
3. Progress Report,
4. Final Presentation,
5. Final Report.



# Outline

Lesson Plan

Textbook

Writing about Numbers  
Math. Modeling

Project

Work Statement  
Glossary

# What is Work Statement

This is the written proposal and definition of the project and constitutes the team's "contract" with the sponsor. It should be approximately 2-5 pages long. It sets forth the nature of the project, the specific objectives of the project, the results expected, and the "deliverables" for the project. The scope of the project must be within the timetable for the program and that the deliverables are reasonable and appropriate; given the nature of research, it should not include promises that the team cannot be certain to achieve. It is ultimately given to the sponsor for review and signature.



# Template 1

1. Abstract
2. Background
3. Problem description
4. Approach ( “time permitting” clause for some work)
5. Schedule (dates for completing milestones and tasks and for deliverables)
6. Milestones (major checkpoints your team will use to stay on track)
7. Deliverables (specific work products you will deliver to the sponsor)

## Templates 2

1. Introduction
2. Problem background
3. Mathematical background
4. Computing background
5. Possible solutions and project objectives
6. Deliverables (“time permitting” clause for some work)
7. Timeline

## Template 3

1. Project background
2. Goals (major direction you see the work aimed at, not necessarily what you bid to do)
3. Proposed mathematical approach
4. Objectives (specific aims of your project, and schedule of results you expect to achieve)
5. Optional objectives
6. Deliverables
7. Milestones
8. Work flowchart
9. Schedule

# Template 4

1. Abstract
2. Problem background
3. Problem description
4. Approach
5. Deliverables
6. Timetable
7. Team members

# Work Statement

In the initial segment ( “Abstract”, “Introduction”, “Background” )

- Brief description of the company
- Major product lines(s)
- A brief (abstract) description of the project

# Work Statement

## Throughout

- Spell out terminology – avoid undefined jargon or acronym
- When options must be resolved, give dates by which they must be resolved
- Give modest objectives, not boastful ones

# Work Statement

## List of deliverables should include

- Site visits (to be arranged)
- Midterm oral presentation
- Midterm report
- Final presentation
- Final report
- Software (if appropriate)
  - Specify sponsor-approved OS, platform
  - Documentations

# Glossary I

## GOAL

The overall, long range, end result that your research is aimed at, what you are trying to achieve ultimately. Stating a goal does not mean you believe you will get there this time around. It is the grand view towards which you strive. The goal of AIDS research is to find a cure for AIDS.



# Glossary

## OBJECTIVES

The specific things you will try to achieve in your project, the immediate targets of your research. Your objectives spell out how you have parsed the problem of heading towards the goal into smaller pieces that you will work on. The objectives set practical limits on your work. They point to where the project can reasonably expect to wind up. It should be clear that the objectives fit into and work towards the long-range goal.

# Glossary

## TASKS

These are the specific things you will do in order to achieve your objectives. The tasks drive your determination of what skills and other resources (such as data, software, hardware, written materials, work environment) will be needed for your project. If among the resources needed are ones that must be supplied by the sponsor, then you will need to specify these items in your Work Statement.

# Glossary

## DELIVERABLES

The things you promise to deliver to the sponsor. For a project, these include a mid-term and final report, a mid-term presentation and a final presentation on Projects Day. They may also include site visits to the sponsor (usually one near the beginning of the project to get acquainted with the sponsor, and one after Projects Day to present the work at the sponsor's location), software, perhaps hardware in some cases, written results of literature searches, white papers (i.e., written background information on such things as plans, methods or concepts prepared for internal use), etc. These additional items are to be decided by you in consultation with your sponsors mentor.

# Glossary

## MILESTONES

A list of specific accomplishments that you may use to mark progress and maintain pace and coordination within your project. They are used to help your team stay on track and to determine the success of a chosen line of attack on your problem. Milestones may or may not be included in your Work Statement, but you should definitely think these through for your own use as you plan your project and Work Statement. They are check-points for you (and for your sponsor, if they are included in the Work Statement), not necessarily deliverables. You may want to specify major milestones in your Work Statements to indicate what you would do if your research leads to the conclusion that some objective cannot be accomplished. For example, "if by such a date we have found it impossible to achieve X, then we will begin Y." Research is exploration of the unknown, so you may encounter an intractable obstacle and need to work around it. You can't know everything ahead of time. Give some thought to this and try to allow for milestones by which you can judge where you are and what you need to do to proceed effectively in the event you don't meet a milestone.

# Glossary

## SCHEDULE

This specifies when you will finish major parts of your research and provides a timetable for completion of deliverables. Internally, you should maintain as fine-grained a schedule as you need to keep your team coordinated and on track, but in your Work Statement it is best to make the schedule and list of deliverables as modest as the sponsor will allow.