Presenting a New Course for Fall 2007:

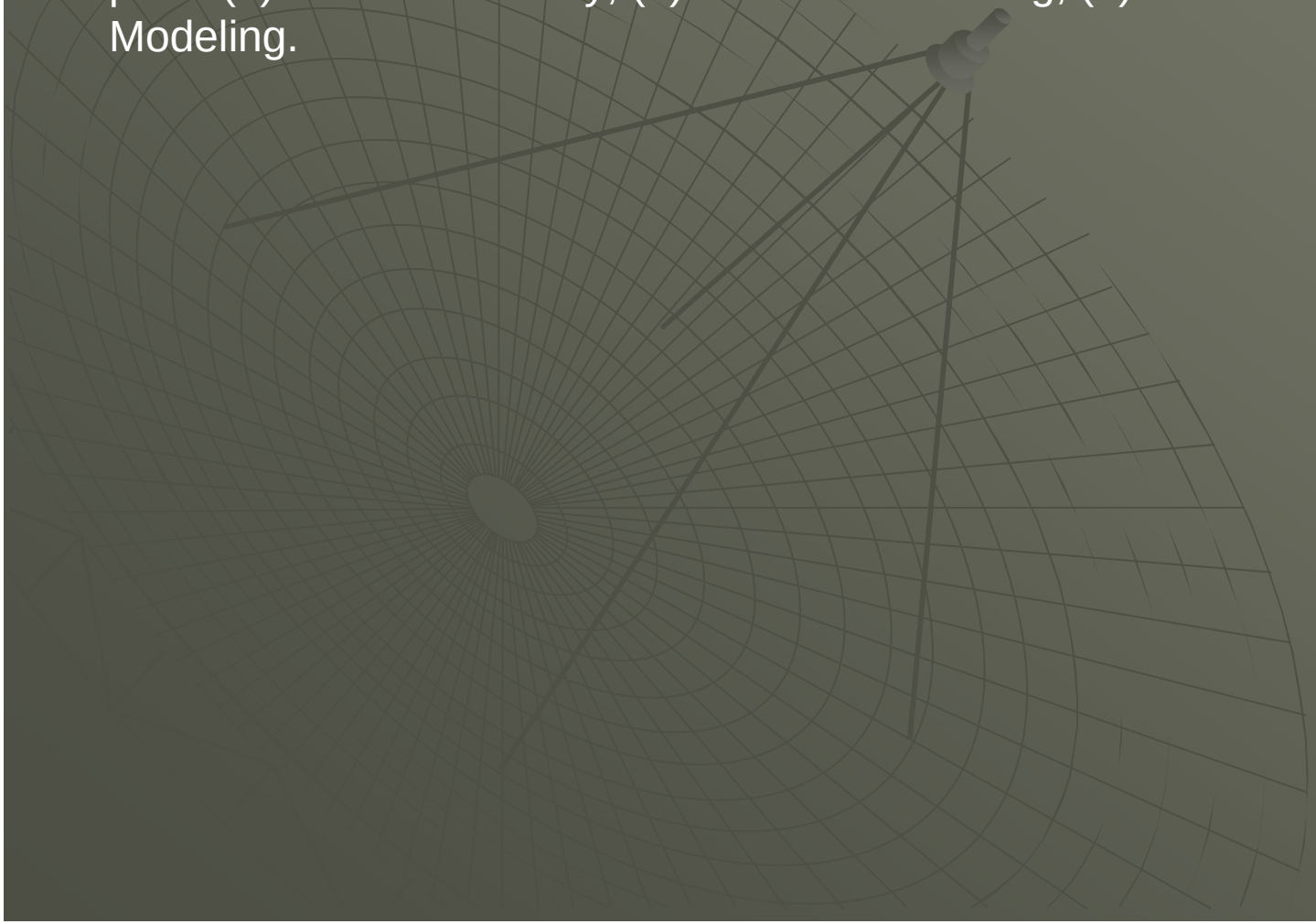
MATH 181

Environmental Awareness through Mathematical Modeling

The course is intended for non-science majors who need a first year mathematics course.

While it would fall into categories such as "Quantitative Reasoning/Literacy" or "Liberal Arts Mathematics," it is best described as a capstone experience with real-world mathematics in which elementary concepts and techniques are applied in sophisticated ways.

Catalog Description Students develop mathematical literacy and environmental awareness as they model natural processes using algebraic, graphical, and numerical methods, and analyze data quantitatively to assist in objective decision making. Collaborative projects are incorporated into each part: (1) Basic Numeracy; (2) Function Modeling; (3) Difference Equation Modeling.



Learning Outcomes

Upon successful completion of the course the student will be able to:

1. Apply principles and techniques of measurement.
2. Compare, estimate, and predict using proportions, percent, and probability.
3. Create and analyze charts and graphs representing univariate or bivariate data.
4. Model linear change, and exponential growth and decay using equations, tables, and graphs
5. Approximate models using the straightedge method or regression of transformed data.
6. Use power law distributions to predict frequency of catastrophic events and define fractals.
7. Describe sequences using first order difference equations and their corresponding solution equations.
8. Model data with linear, exponential, and affine difference equations.
9. Compare the function modeling, and difference equation modeling approaches.
10. Find and classify equilibrium values.
11. Examine logistical models that lead to periodic or chaotic behavior.
12. Explore the effects of harvesting on carrying capacity (sustainability.)
13. Apply systems of difference equations to model stable age distributions, and changes in pollution levels in systems of lakes connected by rivers.
14. Analyze models, assess their accuracy, and use them for prediction.

Using the text:

Quantitative Reasoning and the Environment: Mathematical Modeling in Context

by Langkamp & Hull

Pearson Prentice Hall, 2007

(about 350 pages, paperback)

Quantitative Reasoning and the Environment

MATHEMATICAL MODELING IN CONTEXT

GREG LANGKAMP JOSEPH HULL

The text is . . .

… **traditional**. Each chapter presents introductory material, worked examples, multiple student problems, solutions to odd exercises, and a summary.

… **reform** in that it investigates material through a synthesis of algebraic, graphical, numerical, and verbal approaches.

TI-83/84

Calculator Required.

The emphasis of this course is on analyzing real environmental information and problems, using mathematics accessible to students with an intermediate algebra background.

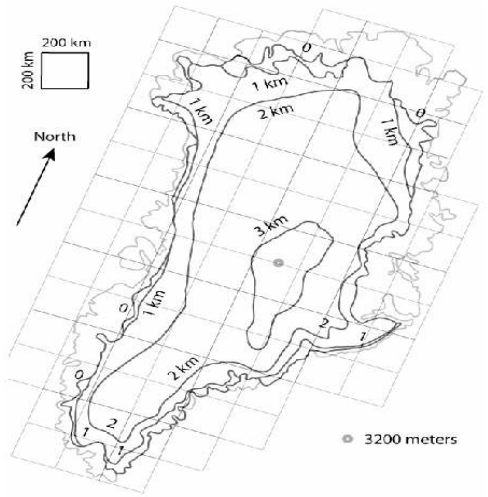
A project offering an opportunity for collaborative problem-solving has been selected as an integrating, culminating experience for each of the three parts.

- ***Part 1: Essential Numeracy (Ch. 1-3)***
- ***Part 2: Function Modeling (Ch. 4-6)***
- ***Part 3: Difference Equation Modeling (Ch. 7-10)***

Chapter 1: Measurement and Units

Mercury and the Inuit of Greenland
Measuring
Accuracy and Precision of Measurement
Estimation and Approximation
Units of Measurement
Unit Conversion
Compound Units
Units in Equations and Formulas
Unit Prefixes
Scientific Notation and Order of Magnitude
Powers of 10 and Logarithms
Logarithmic Scales

Science in Depth: *Global Warming*
Chapter Project: *Melting of the Ice Caps*



The Chapter 1 project focuses on measuring the volume of ice in the Greenland ice sheet, converting global ice volume to water volume, and calculating the subsequent rise in sea level. The project has a hands-on feel, as students generate their own data through measurement. There's a solid dose of approximation and decision making, two important skills in quantitative literacy. For many students, this will be their first exposure to

Chapter 2: Ratios and Percentages

Ratios
Normalization
Percentage as a Type of Ratio
Parts per Thousand
Parts per Million and Parts per Billion
Percentage as a Measure of Change
Percentage Difference and Percentage Error
Proportions
Probability
Recurrence Interval

Science in Depth: *Sinkholes and Lakes*
Chapter Project: *Measuring Habitat of Florida Lakes*

Chapter 3: Charts and Graphs

Pie Charts
Bar Charts
Frequency Histograms
Using Technology: Histograms
Relative Frequency Histograms
Scatterplots
Using Technology: Scatterplots
Line Graphs

Science in Depth: *Energy Demand and the Arctic National Wildlife Refuge*
Chapter Project: *U.S. Energy Flows*

Chapter 4: Linear Functions and Regression

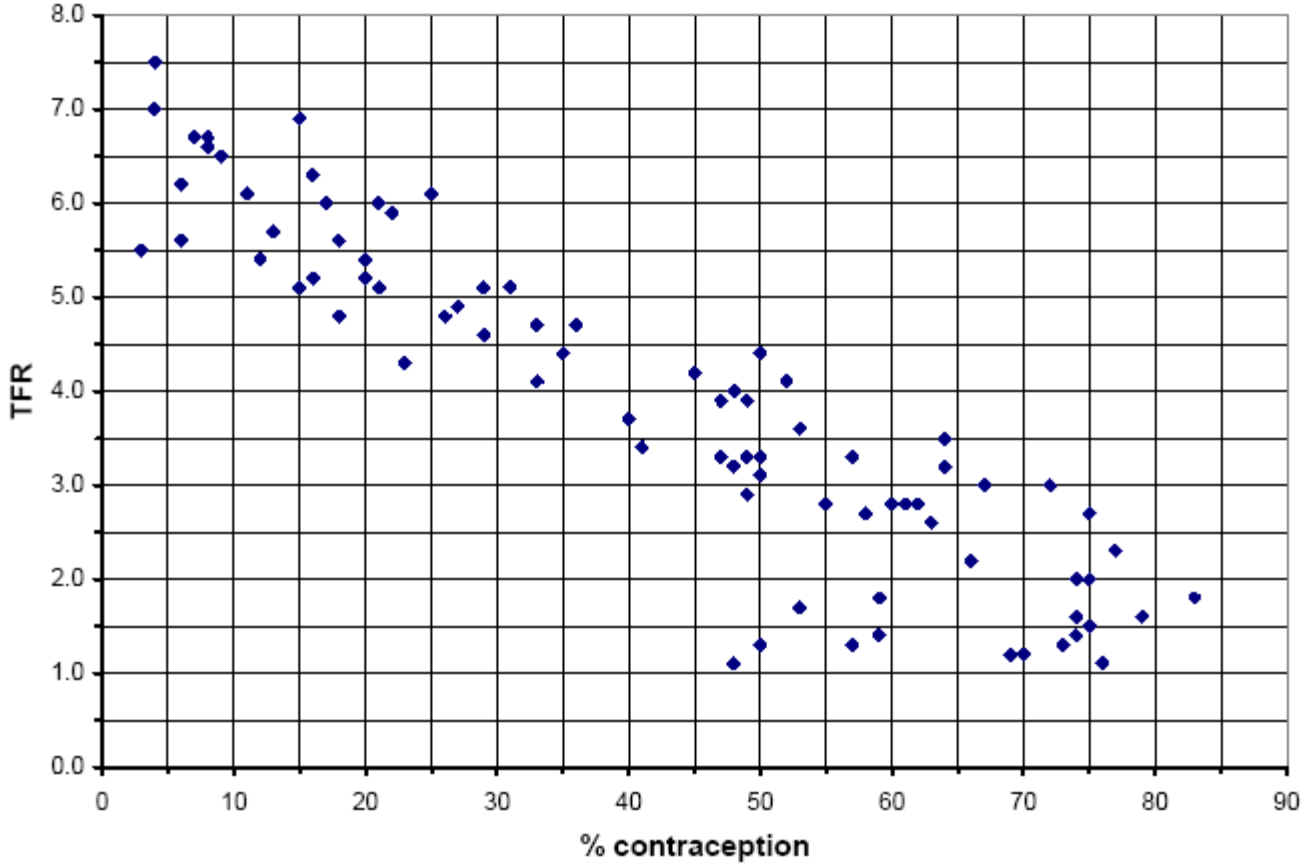
Modeling with Linear Functions
Units of Measure in Linear Equations
Dependent versus Independent Variables
Graphing Linear Equations
Using Technology: Graphs and Tables
Approximating Almost-Linear Data Sets
straightedge method
least squares regression
Using Technology: Linear Regression
The Correlation Coefficient "r"
Using Technology: The Correlation Coefficient
Correlation Fallacies

Science in Depth: *Population Growth*
Chapter Project: *Fertility Rates in Developing Countries*

Data:
The data that you will examine in this project are from a Johns Hopkins School of Public Health Report titled *Why Family Planning Matters*, published in 1999. This report has data on numerous population variables for 139 developing countries. For this project, you will examine 6 of these variables: family planning through the use of contraception, economic wealth, women's age at marriage, infant mortality, female education, and total fertility rate. In the report, only 81 of the 139 countries have data for all 6 of these categories. The data for those 81 countries are provided on the attached 2-page data sheet.

More specific definitions of the variables are as follows:

CONTR	Percentage of couples using contraception as a family planning option. Source: United Nations.
GDP	Gross Domestic Product is the total output of goods and services per capita in 1997 U.S. dollars. GDP is a commonly-used indicator of economic wealth.
MEDAG	The median age of women at first marriage. The median is the number that lies in the middle of a data set when the data are arranged in order. Sources: U.S. Agency for International Development's Demographic and Health Surveys and United Nations.
MORT	Number of infant deaths (0 to exactly 5 years of age) per 1,000 live births. Source: UNICEF
SCHO	The percentage of females enrolled in secondary school. Source: UNICEF
TFR	Total Fertility Rate is the average number of children a woman would have during childbearing years (ages 15 to 49) at current birth rates. Source: Population Reference Bureau.


8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
TFR
0
10
20
30
40
50
60
70
80
90
% contraception

Chapter 5: Exponential Functions and Regression

Exponential Rates and Multipliers
The General Exponential Model
Finding Exponential Functions–the More General Case
Solving Exponential Equations
Doubling Times and Half-Lives
Approximating Almost-Exponential Data Sets
straightedge method
least squares regression
Using Technology: Exponential Regression

Science in Depth: *Chicken Nation*
Chapter Project: *Broiler Chicken Production in the U.S.*

Chapter 6: Power Functions

Basic Power Functions
Solving Power Equations
Approximating Power-Like Data Sets
straightedge method
least squares regression
Using Technology: Power Regression
Power Law Frequency Distributions
Power Law Distributions and Fractals
Recurrence Intervals

Science in Depth: *Earthquakes and Fractals*
Chapter Project: *A New Model for Earthquakes*

Chapter 7: Introduction to Difference Equations

Sequences and Notation
Modeling with Difference Equations
Linear Difference Equations
Exponential Difference Equations
Why Use Difference Equations?
Affine Difference Equations
Using Technology: Difference Equations

Science in Depth: *The Politics of Immigration*
Chapter Project: *Human Population and Migration*

Chapter 8: Affine Solution Equations and Equilibrium Values

The Solution Equation to the Affine Model
Equilibrium Values
Classification of Equilibrium values
Revisiting the Affine Solution Equation

Science in Depth: *Get The Lead Out*
Chapter Project: *Lead in the Body*

Chapter 9: Logistic Growth, Harvesting and Chaos

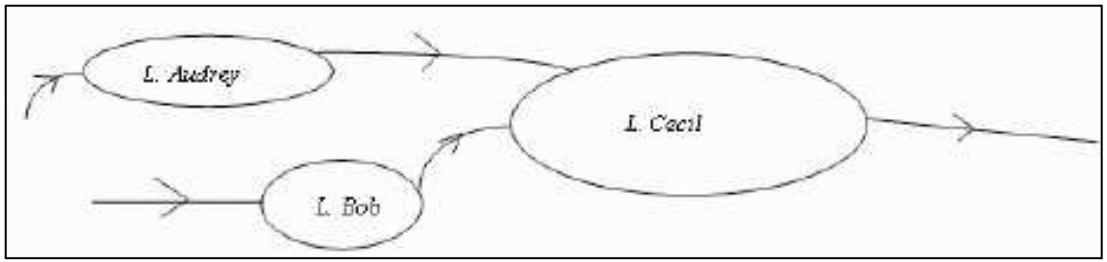
Modeling Logistic Growth with Difference Equations
Logistic Equilibrium Values
Harvest Models
Periodic Behavior
Chaotic Behavior

Science in Depth: *Harvesting and Sustainable Forestry*
Chapter Project: *Harvesting and Sustainability*

Chapter 10: Systems of Difference Equations

Systems Modeling
Using Technology: Systems of Difference Equations
Exponential Change and Stable Age Distributions
What Else Besides Populations?

Science in Depth: *A River Runs Through Europe*
Chapter Project: *Water Pollution in a System of Lakes*



This project is an extension of the lakes Erie and Ontario example from the text. It requires modeling 4 scenarios in which various combinations of flow patterns are examined and involves a fair amount of quantitative reasoning about flows and volumes.