Preliminary Proposed Second Year Course

MA 226
An Introduction to Applied Mathematics

http://www4.ncsu.edu/eos/users/w/white/www/white/ma226a.pdf

by
R. E. White

(draft date 02-18-00)

This is a one semester required course for math majors, which would be taken after completion of two semesters of calculus. It will consist of about five modules on a selection of applications of mathematics chosen from:

- differential equations,
- abstract algebra,
- discrete,
- industrial,
- statistical and
- others.

This course be useful to the student because:

- introduces additional applications in more depth,
- serves as a guide for future work such as
  - selection of possible year course on applied math
  - selection of possible double major
  - identification of research groups
  - identification of intern programs
- introduces nontraditional mathematics topics.

Currently, there are eight possible three week modules:

- Heat and mass transfer and geometric series in nD (R. E. White)
- Price, population and temperature data and least squares (R. E. White)
- Scaling and perturbation methods (M. A. Haider)
- Chemical reaction models: analysis and numerical solution (Z. Li)
- Mathematics in genetics (J. Bishir)
- Discrete and continuous models of population growth (J. Bishir)
- Cryptographic schemes (E. Stitzinger)
- Acoustic waves and boundary conditions (H. T. Tran)

Module of MA 226

Heat and Mass Transfer and Geometric Series in nD

by
R. E. White
(draft date 01-13-00)

Module Objectives:

introduce diffusion and advection models
jump from 1D to nD models
stability and convergence in nD
study $y^{k+1} = Ay^k + b$

Module Category:

differential equations and discrete models

Module Future Objectives:

could lead students to MA 401,2 or to MA 427,8
could lead to double major with CSC or PHY

Module Outline:

Lecture 1. Newton cooling and stability
Lecture 2. Discrete versus continuous
Lecture 3. Fourier heat law
Lecture 4. Discrete Fourier heat law and stability
Lecture 5. Pollutant transfer
Lecture 6. Pollutant transfer, upwind discretization and stability
Lecture 7. Steady state y = Ay + b.
Lecture 8. Convergence in nD and infinity norm
Lecture 9. Stability in nD and matrix norm

Module of MA 226

Price, Population and Temperature Data and Least Squares

by
R. E. White
(draft date 01-13-00)

Module Objectives:

introduce curve fitting to given data
jump from 1D and 2D to nD least square models
nonlinear least squares
statistical measure of fit

Module Category:

Industrial and statistical models

Module Future Objectives:

could lead students to ST 371,2
could lead to double major with ST
could lead to intern position

Module Outline:

Lecture 1. Price models
Lecture 2. Normal equations
Lecture 3. Logistic population models
Lecture 4. Parameter identification for population model
Lecture 5. Heat transfer
Lecture 6. Lab session at CRSC
Lecture 7. Parameter identification for heat model
Lecture 8. Nonlinear least square methods
Lecture 9. Statistical analysis of fit

Module of MA 226

Scaling and Perturbation Methods

By
M.A. Haider
(draft date 02-11-00)

Module Objectives:

Introduce analytical methods for solving nonlinear applied math problems
Encourage critical thinking in developing approximate solutions
Illustrate applications of Taylor series and limits
Illustrate practical use of symbolic computation software

Module Category:

Differential equations and industrial

Module Future Objectives:

Could lead students to MA401, 402, 430

Module Outline:

Lecture 1: Dimensional analysis and scaling
Lecture 2: Asymptotic expansions of algebraic functions
Lecture 3: Regular perturbation applied to differential equations
Lecture 4: Eigenvalue problem for a whirling elastic string
Lecture 5: Use of symbolic computation software
Lecture 6: Singular perturbation and matched asymptotic expansions
Lecture 7: The nonlinear pendulum
Lecture 8: Method of multiple scales
Lecture 9: Motion of a forced oscillator near resonance

Module of MA 226

Chemical Reaction Models: Analysis and Numerical Solution

by
Zhilin Li
(draft date 02-09-00)

Module Objectives:

introduce chemical reaction models
phase plane analysis and limit cycle
stiff systems and difficulties
numerical methods and Matlab

Module Category:

differential equations and numerical methods

Module Future Objectives:

could lead students to MA 514, MA 531-532, MA 580, MA 584, MA 587
could lead to double major with CSC or chemical engineering

Module Outline:

Lecture 1. Derive the chemical reaction models
Lecture 2. Model analysis and phase planes
Lecture 3. Analytic solution for some simple models
Lecture 4. What is a stiff system?
Lecture 5. ODE solvers in Matlab. Which solver should we use?
Lecture 6. The Brusselator model.
Lecture 7. The Oregonator model.
Lecture 8. Chemical tank reactor stability.
Lecture 9. The dynamics of a reservoir system.

Module of MA 226

Mathematics in Genetics

by

John Bishir

(draft date 02-15-00)

Module Objectives:

Introduce Basic Concepts of Probability
Illustrate how Mathematics is Used in Genetics
Introduce Discrete Recursions
Illustrate Application of Mathematics to
- Analysis of Plant and Animal Breeding Strategies
- Hereditary Diseases in Humans

Module Category:

Probability and Discrete Recursions

Module Future Objectives:

Could lead students to MA 421, 432, or 571
Could lead to double major or concentration in GN

Module Outline:

Lectures1, 2.	Some Basics of Probability
Lecture 3.	Mendelian Inheritance
Lecture 4.	Population Genetics & Hardy-Weinberg Law
Lecture 5.	ABO and Rh Blood Groups
Lecture 6.	Hereditary Genetic Diseases and Defects
Lecture 7.	Inbreeding in Plants and Animals
Lecture 8.	Analysis of Plant and Animal Breeding Strategies
Lecture 9.	Human Genetic Counseling

Module of MA 226

Discrete and Continuous Models of Population Growth

by

John Bishir

(draft date 02-15-00)

Module Objectives:

Illustrate the process of Mathematical MODELING
(as opposed to analyzing mathematical models)
Modeling in Ecology and Demography
Dynamical Systems and their Analysis
Stability and Chaos

Module Category:

Differential Equations and Discrete Recursions

Module Future Objectives:

Could lead students to MA 432, 519, or 571
Could lead to double majors with, or concentrations in,
ZO, BO, or FOR

Module Outline:

Lecture 1.	Modeling a Wildebeest Population
Lecture 2.	Analysis of the Wildebeest Model
Lecture 3.	Discrete dynamical Systems
Lecture 4.	Stability and Chaos
Lecture 5.	Continuous Dynamical Systems - The Exponential and Logistic Models
Lecture 6.	U.S. and World Population Growth
Lectures 7-9.	Modeling the Interaction between Vegetation and Zebra in an African Game Park

Module of MA 226

Cryptographic Schemes

by
E. Stitzinger
(draft date 02-18-00)

Module Objectives:

Illustrate cryptographic algorithms
Prime numbers and factorization
Probabilistic methods

Module Category:

Abstract algebra and number theory

Module Future Objectives:

Could lead students to MA 407, 437
Could lead to double major with CSC

Module Outline:

Lecture 1.	Introduction to cryptographic schemes
Lecture 2.	RSA
Lecture 3.	Relevant number theory
Lecture 4.	Prime number determination
Lecture 5.	Fermat's little theorem
Lecture 6.	Prime number factorization
Lecture 7.	Pollard p-1 and rho tests
Lecture 8.	The inverse problem
Lecture 9.	Implementation via symbolic manipulators

Module of MA 226

Acoustic Waves and Boundary Conditions

By

H.T. Tran

Module Objectives:

In this module, we consider several types of boundary conditions in the context of the wave equation, which arises in any mathematical analysis of phenomena involving the propagation of waves in a continuous medium. For example, the studies of acoustic waves, water waves, and electromagnetic waves are all based on this equation. More specifically, this module will study two types of boundary conditions for acoustic waves propagation in a PVC pipe. Experiments with two different boundary conditions, hardwall and foam, will be carried in the CRSC/Math laboratory. These data will then be used to estimate unknown parameters in the models for boundary conditions. The students will learn the interplay between the differential equation and the boundary condition(s) and how to model measured data that are typical of real-world materials and conditions.

Module Future Objectives:

Could lead students to MA401/402, MA573/574

Module Outline:

Lecture 1,2.	Development of the wave equation from first principles
Lecture 3.	Development of several types of boundary conditions
Lecture 4.	Discuss experimental procedures and data collection
Lecture 5,6.	Formulate the least square problem for parameter estimation
Lecture 7.	Visit to the CRSC/Math laboratory for data collection
Lecture 8,9.	Analysis of data