Introduction

System: An assemblage of objects joined in some regular interaction or independence

Real-world systems
- Observed behavior or phenomenon

Mathematical world
- Models
- Mathematical operations and rules
- Mathematical conclusions
Reaching Conclusions about real-world systems Fig 2.2

Real-World Behavior

Observation
Simplification

Model

Analysis

Real-world conclusions

Interpretation

Mathematical conclusions

Trials
A Rough Modeling Procedure

1. Through observation indentify primary factors involved in real-world behavior possible making simplifications

2. Conjecture tentative relations among the factors

3. Apply mathematical analysis to resultant model

4. Interpret mathematical conclusions in terms of real-world problems

Giordano et al. pp. 54
Modeling Process as Closed System- Fig 2.3

- Real-World Data
  - Simplification
  - Verification
  - Real-world explanations or predictions

- Model
  - Analysis
  - Mathematical conclusions
  - Interpretation
The Nature of Mathematical Models

A **mathematical model** is a mathematical construct designed to study a particular real-world system or phenomenon

- **Phenomenon of interest (Fig 2.4)**
  - Mathematical Representation
    - Model Construction
    - Model Selection
  - Replication of Behavior
    - Experimentation (*direct*)
    - Simulation (*indirect*)
Properties of a Model

**Fidelity**: preciseness of model’s representation of reality

**Costs**: total cost of modeling process

**Flexibility**: ability to change and control conditions affecting the model as required data are gathered.

Consider properties across models types – Fig 2.5

real world observations / experiments / simulations / constructed models / s elected models
Construction of Mathematical Model

1. Identify the Problem
2. Make assumptions
   a. Identify & classify variables
   b. Determine interrelationships between variables & sub-models
3. Solve the Model
4. Verify the Model
   a. Does it address problem?
   b. Does it make common sense?
   c. Test it with real-world data
5. Implement the Model
6. Maintain the Model
Scientific Method

1. Make some general observations of phenomenon
2. Formulate a hypothesis
3. Develop a method to test the hypotheses
4. Gather data for test
5. Test hypothesis using data
6. Confirm or reject hypothesis