

1. INTRODUCTION

WHAT IS A 'MODEL' ?

- CONCEPTUAL MODEL / MENTAL MODEL
- SCALE MODEL
- PHYSICAL MODEL
- MATHEMATICAL MODEL

WHAT IS A MATHEMATICAL MODEL?

- ✓ $\Sigma F = m \cdot a$ (Dynamics, or $\Sigma F = 0$ for static systems)
- ✓ $PV = nRT$ (Ideal gas)
- ✓ $h_f = f \frac{L}{D^5} Q^2$ (head loss in pipeline)

- Typically expressed as differential or difference equations, or algebraic equations
 - In general, described by a system of such equations (i.e. more than 1 equation, to be considered simultaneously)
 - Expresses relationships between variables and model parameters, such that if we specify model parameter values, we can solve for the model variables (either analytically or numerically)
 - Usually have flexibility with which modeled values are considered parameters and which are considered variables, depending on context.
- Constant values

A Classification of Mathematical models.

Descriptive

"If I do this, what will happen?"

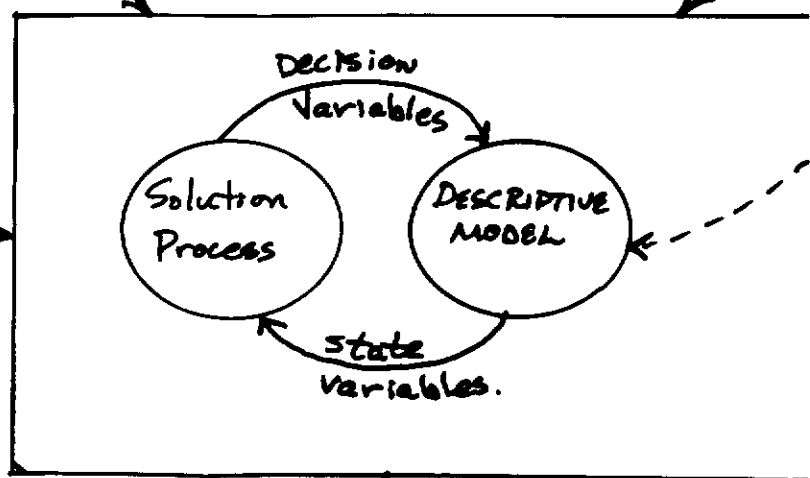
Prescriptive

"If I want this to happen, what should I do?"

Decision Objectives /
Design Objectives

Prescriptive Model
Parameters.

Decision / Design
CONSTRAINTS



DESCRIPTIVE
MODEL
PARAMETERS

Decision that
recognizes objectives
& Constraints

THE PARTS OF A PRESCRIPTIVE MODEL

Think, for example,
a trial & Error
process of decision
making.

DETERMINISTIC

Only one possible outcome for each set of model parameters

STOCHASTIC

Many (possibly infinite) possible outcomes for each set of model parameters.

A model classification based on
Prescriptive / Descriptive ? Stochastic / Deterministic

We will
focus here.

	Deterministic	Stochastic
Prescriptive	Linear Programming Integer Programming Multiobjective Program. Dynamic Program.	Stochastic Program.
Descriptive	Difference Eqs. Differential Eqs. Algebraic Eqs.	Stochastic Differential Equations Queuing Theory Monte Carlo Simulation

Philosophy

"Models are, for the most part, caricatures of reality, but if they are good, then, like good caricatures, they portray, though perhaps in distorted manner, some of the features of the real world."

M. Kac, Science,
166, p695, 1969.

Models (including /especially prescriptive ones) do not provide easy answers to complex problems. They provide a systematic approach for obtaining insights about a particular problem, and thus hopefully for obtaining better solutions.

Some Historically Important Applications of Civil Engineering Systems Analysis. (not inclusive)

- Solid Waste Management
 - Routing of vehicles.
 - Siting of landfills & transfer stations.
- Transportation systems planning
 - highway & railway networks
 - street light timing
 - movement of goods between centers of production & demand
 - Cut & fill in vertical highway alignment
 - Bus route planning
- Water resources and Water Quality.
 - stream waste load allocation
 - groundwater remediation design
 - reservoir system planning for water supply & power production & recreation, etc.
 - water distribution systems operation and design.
- Civil Infrastructure planning
 - sequence of repair of road networks
 - Ordering of construction activities
 - Water/sewer system pipeline replacement