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Unit 1.3

Classification or Types/Taxonomy of Models

Unit I : Syllabus

- Introduction:
  - System
  - Models
  - Discrete event simulation and
  - Continuous simulation
- Discrete Event Simulation:
  - Time-Advance Mechanisms
  - Event Modeling of discrete dynamic systems
  - Single-Server Single-Queue Model
  - Event graphics
  - Monte Carlo Simulation

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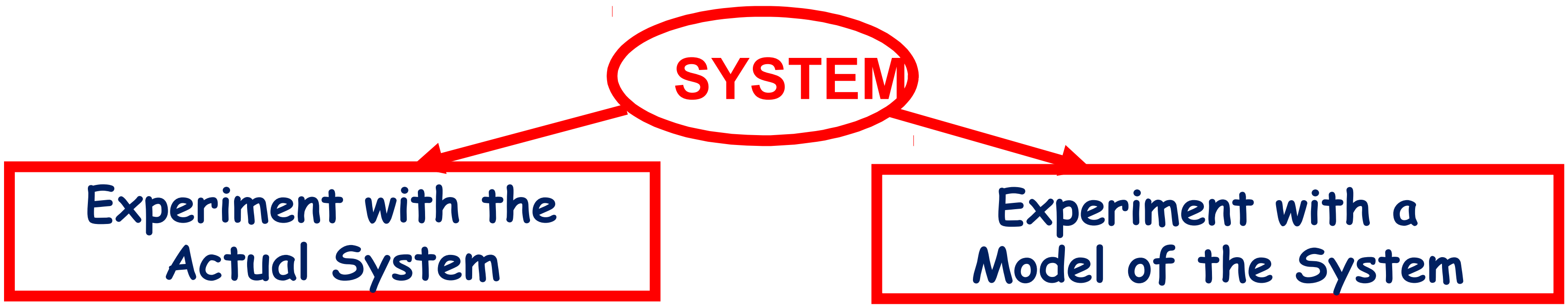


Can be used as a Analysis Tool

Not appropriate for Design Tool

Costly

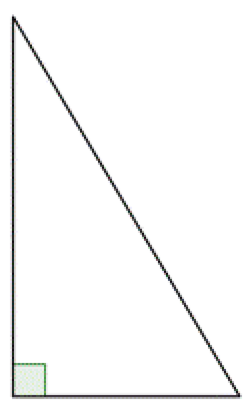
Disruptive

Models Taxonomy

Experiment with a model of the system

Make assumptions that take the form of mathematical or logical relationships

$h^2 = p^2 + b^2$



If P then Q
P
Therefore Q

$$\frac{P \rightarrow Q \qquad P}{Q}$$

Models Taxonomy

Experiment with a model of the system

- Physical Model
- Mathematical Model
- Computer Model

Physical Model

is a scaled down model of actual system,

which has all the properties of the system,

or

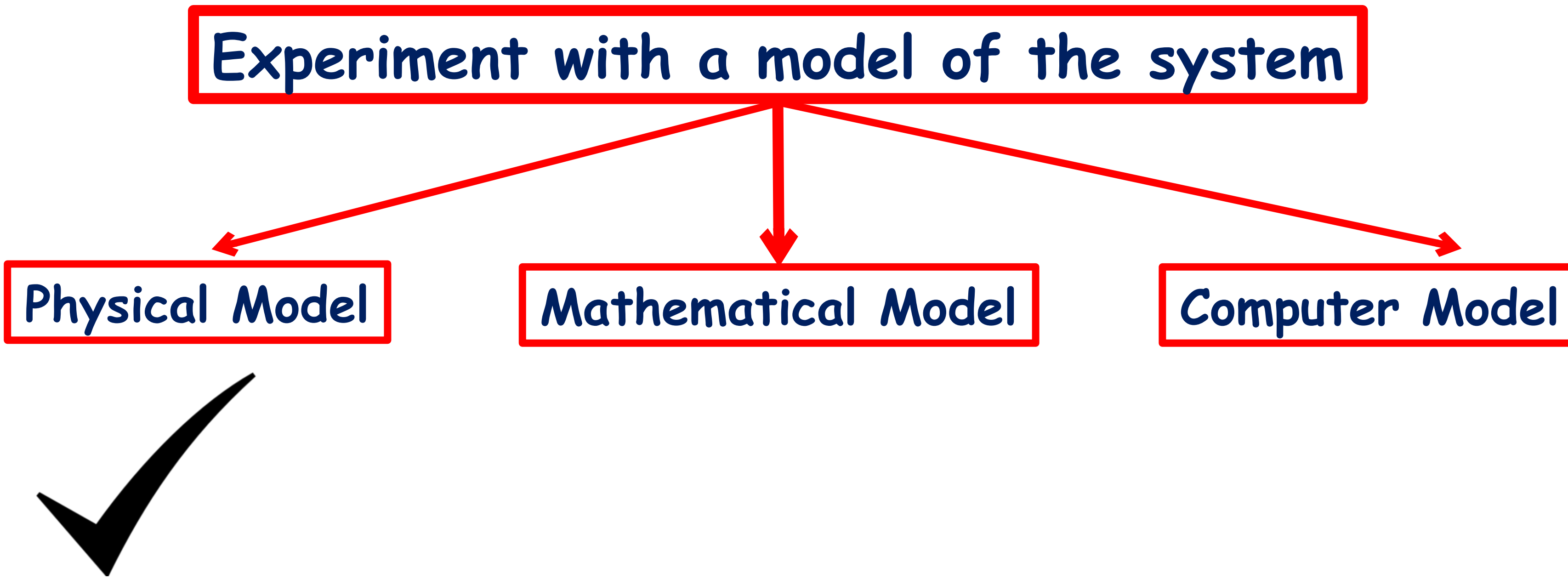
at least it is as close to

the actual system as possible.

Example:

A model of a airplane,
a map,
a globe,
a model of car.

Models Taxonomy



Mathematical Model

Is one in which symbols

and

logic constitute the model.

If P then Q

P

Therefore Q

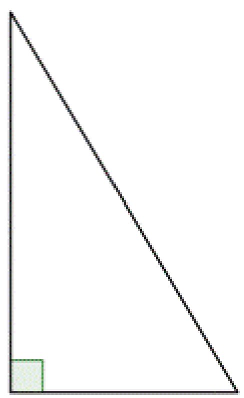
Symbolism can be

a language

or

a mathematical notations.

$h^2=p^2 + b^2$



$$\frac{P \rightarrow Q \quad P}{Q}$$

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Models Taxonomy

Experiment with a model of the system

- Physical Model
- Mathematical Model
- Computer Model

Computer Model

One can design a computer model,

with the help of graphics

as well as mathematics.

This is called Computer Models.

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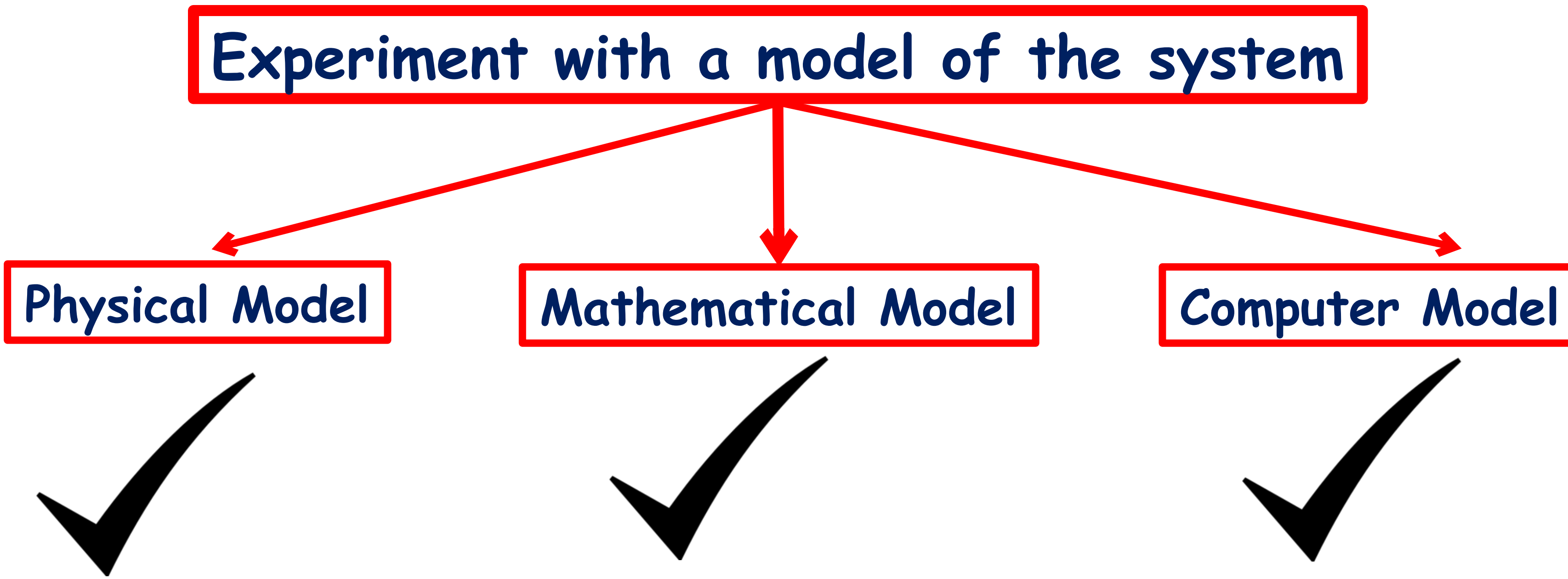
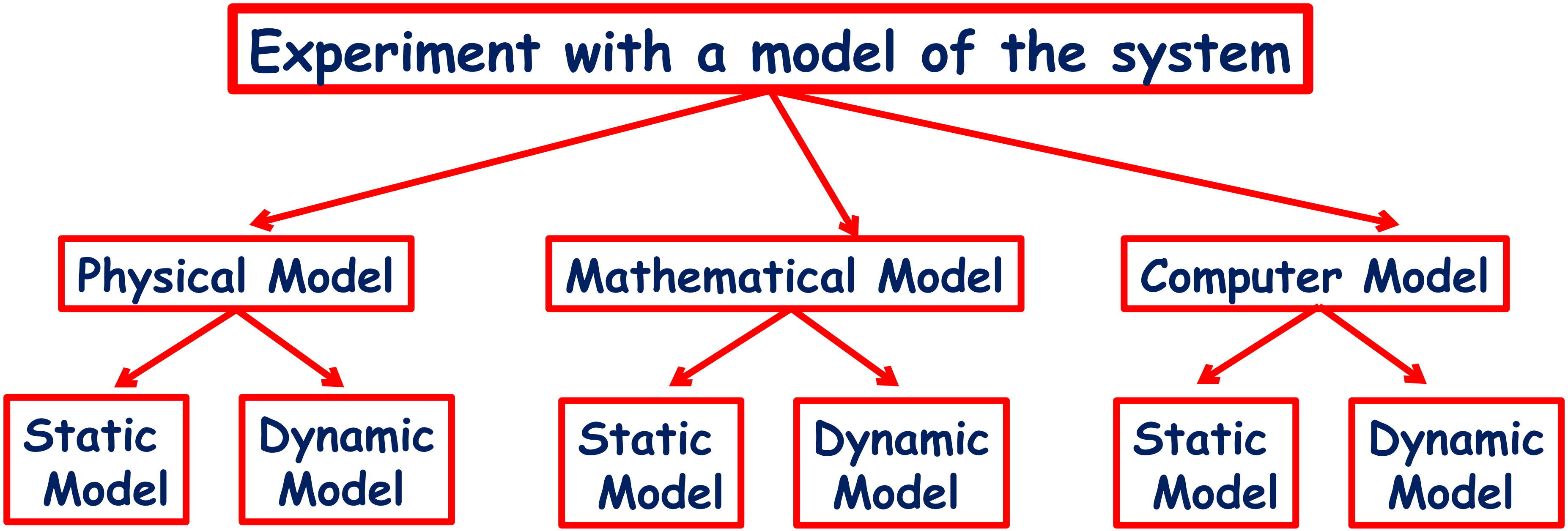
Models Taxonomy



Models Taxonomy



Static Vs. Dynamic Models

Static Models

State variables do not change with time.

Dynamic Models

State variables change over time

Static Vs. Dynamic Models

Static Models

Represents the system at a particular point in time

Time plays no role

Example: Monté Carlo Method

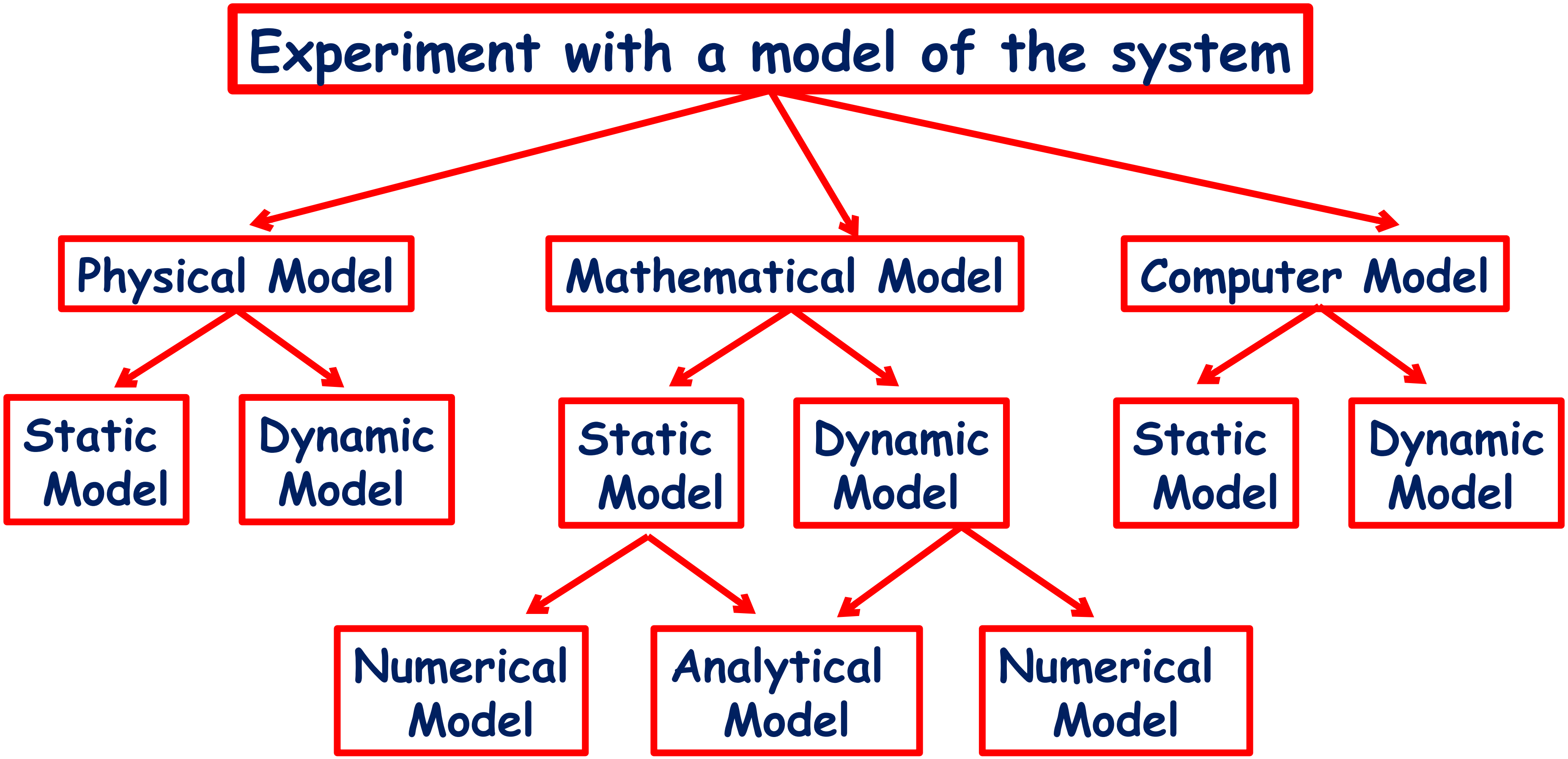
Dynamic Models

Represents a system as it evolves over time

Time plays role

Example : Cars arriving to a parking

Models Taxonomy



Analytical Models

Solves problems by applying
deductive mathematical theory.

If P then Q	$P \rightarrow Q$
P	P
Therefore Q	$\overline{}$ Q

If B. K. Sharma is a Teacher, then B. K. Sharma is poor.

B K. Sharma is a Teacher.

Therefore, B. K. Sharma is poor.

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Numerical Models

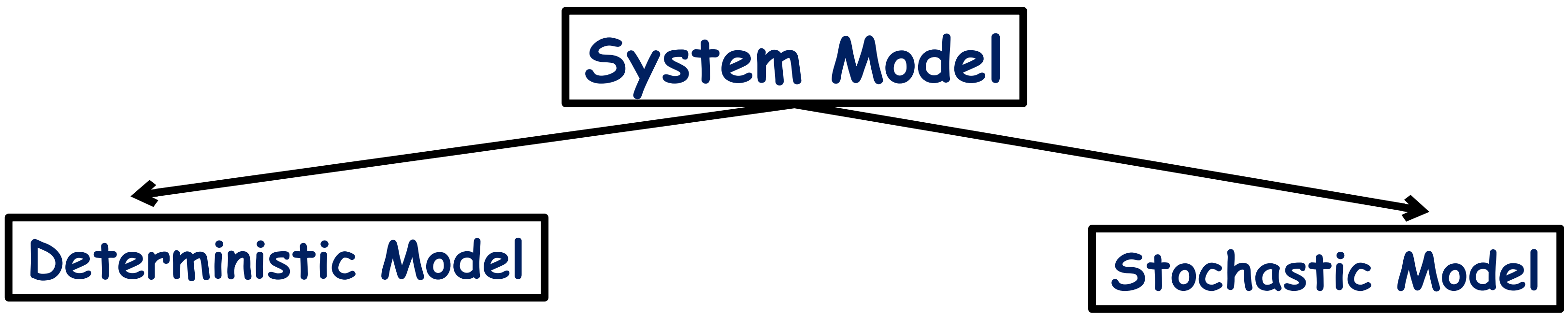
Solves problems by applying

applying computational procedures.

Finding the roots of a non-linear algebraic equations

$$ax^2 + bx + c = 0$$

Models Taxonomy



Is everything for sure or is there uncertainty?

Deterministic Models

The behavior is entire predictable.
The system is perfectly understood,

then

it is possible to predict precisely what will happen.

Stochastic model

The behavior cannot be entirely predicted.

Deterministic Vs. Stochastic Models

Deterministic Models

No probabilistic component in the system.

Example: Worst-Case Analysis of the system

Stochastic Models

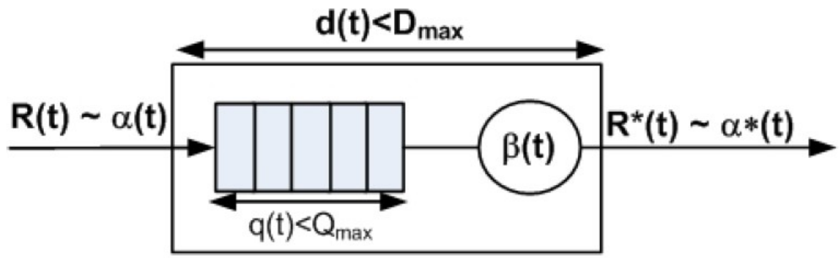
Some components of the system has a probabilistic behavior (Random variable, event probability)

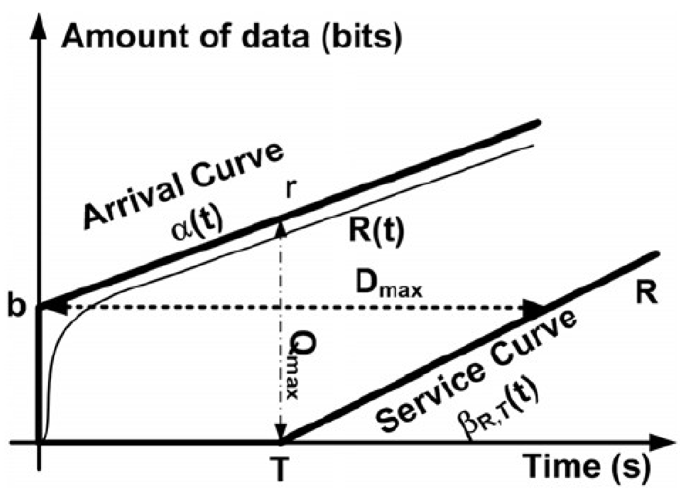
Example: Queuing systems

Example: Deterministic Vs. Stochastic Models

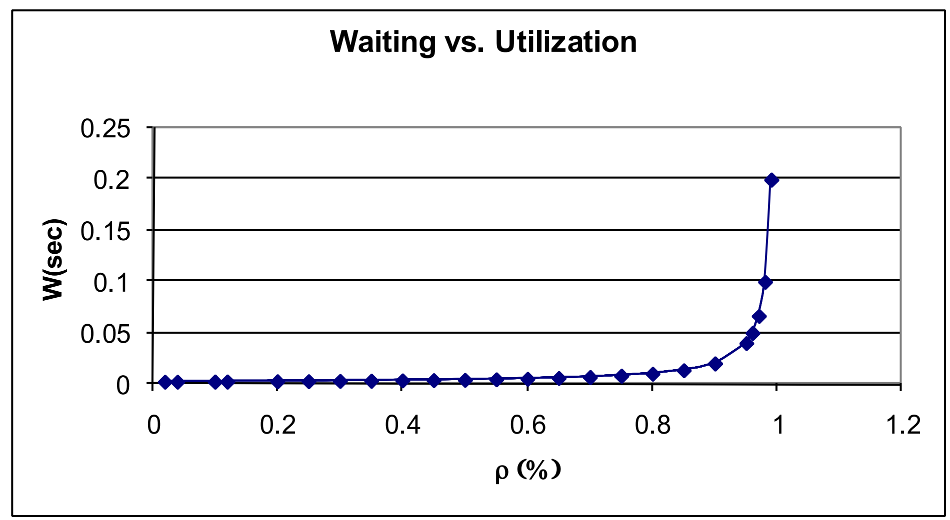
Is everything for sure or is there uncertainty?

Queueing System



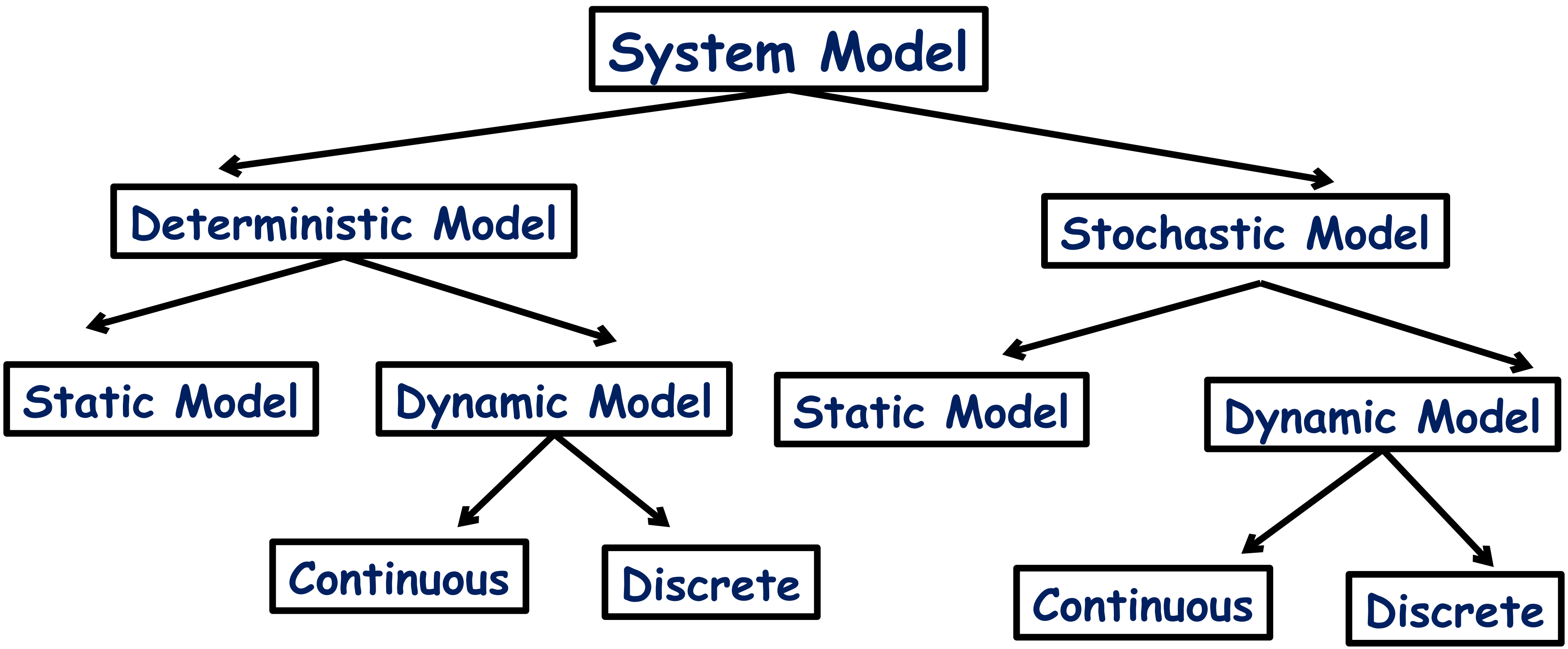


Deterministic Performance
Using Network Calculus



Stochastic Performance
Using Queueing Theory

Models Taxonomy



Discrete Vs. Continuous Models

Discrete Models

The state of the system changes only at discrete points in time.

The state variables change only at a countable number of time / discrete of points in time.

These points in time are the ones at which the event occurs/change in state occurs.

Firing of a gun on an enemy target.

Continuous Models

The state of the system changes continuously

The state variables change in a continuous way, and not abruptly from one state to another (infinite number of states).

Fluid flow in a pipe

Discrete Vs. Continuous Models

Discrete Models

Model of Bank:

Number of customers waiting in line being served.

Queuing, Inventory, Machine Shop Models

Continuous Models

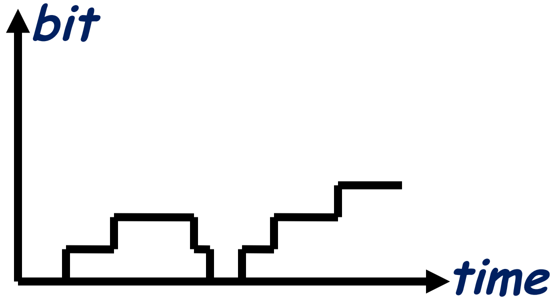
The head of water behind a dam

Chemical Process

Discrete Vs. Continuous Models

Discrete Models

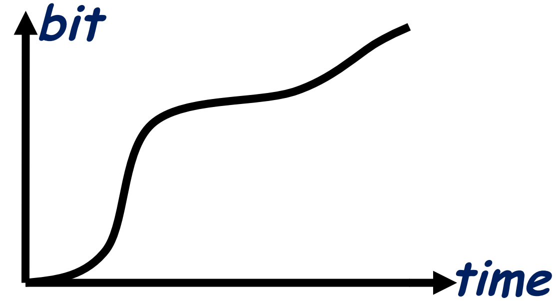
# of cars in a parking lot



Discrete Model

Continuous Models

Bit Arrival in a Queue



Continuous Model

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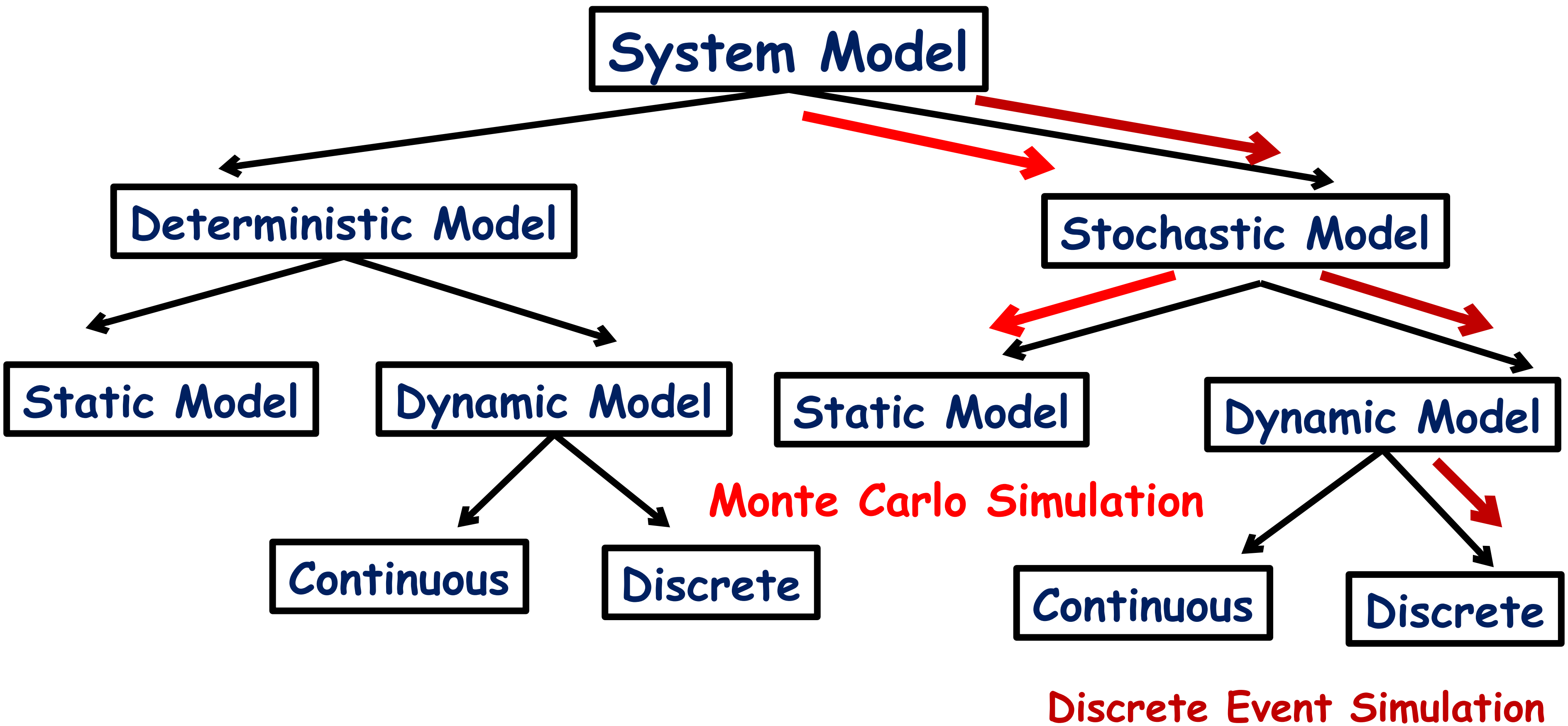
Models Taxonomy



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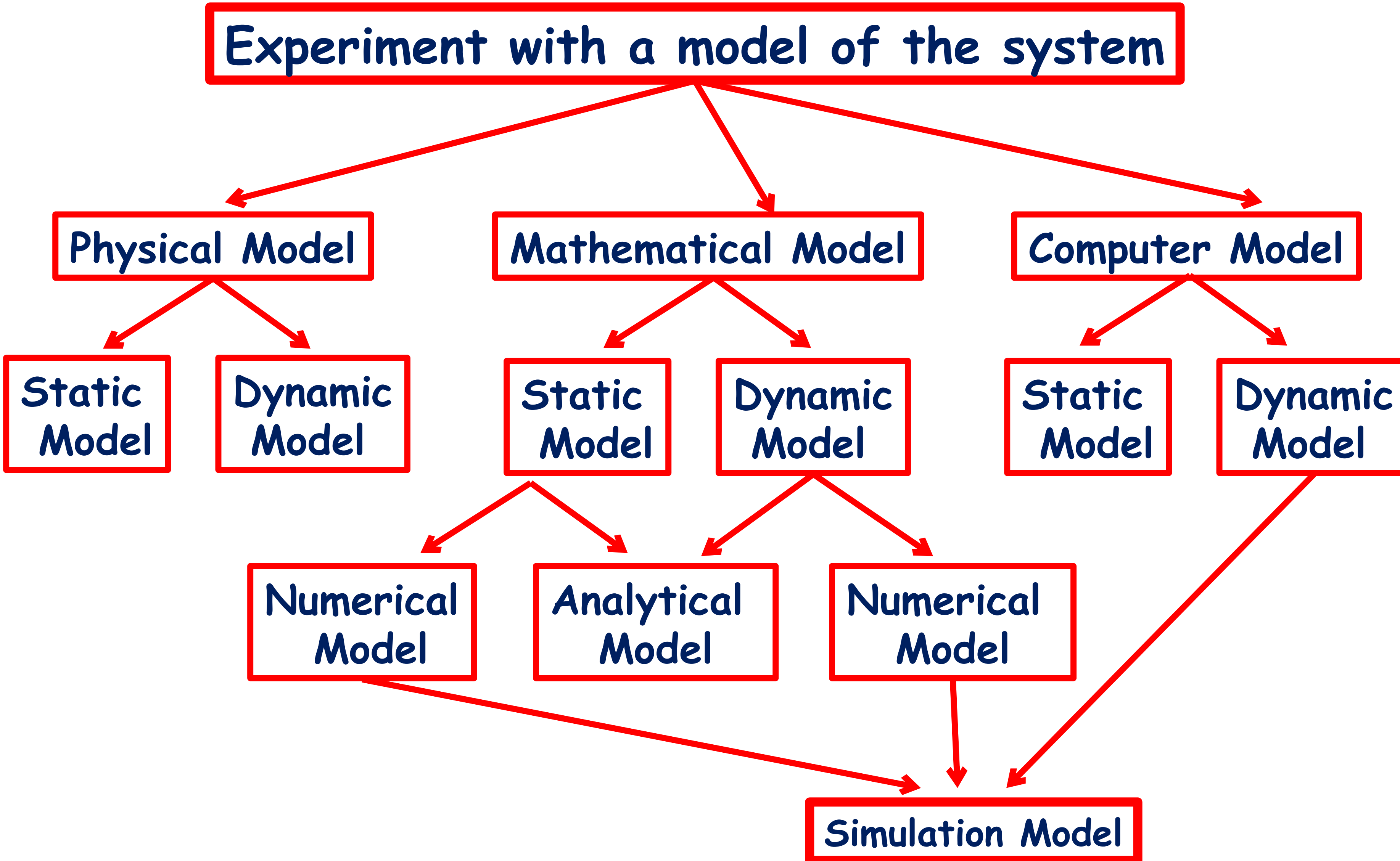
Models Taxonomy



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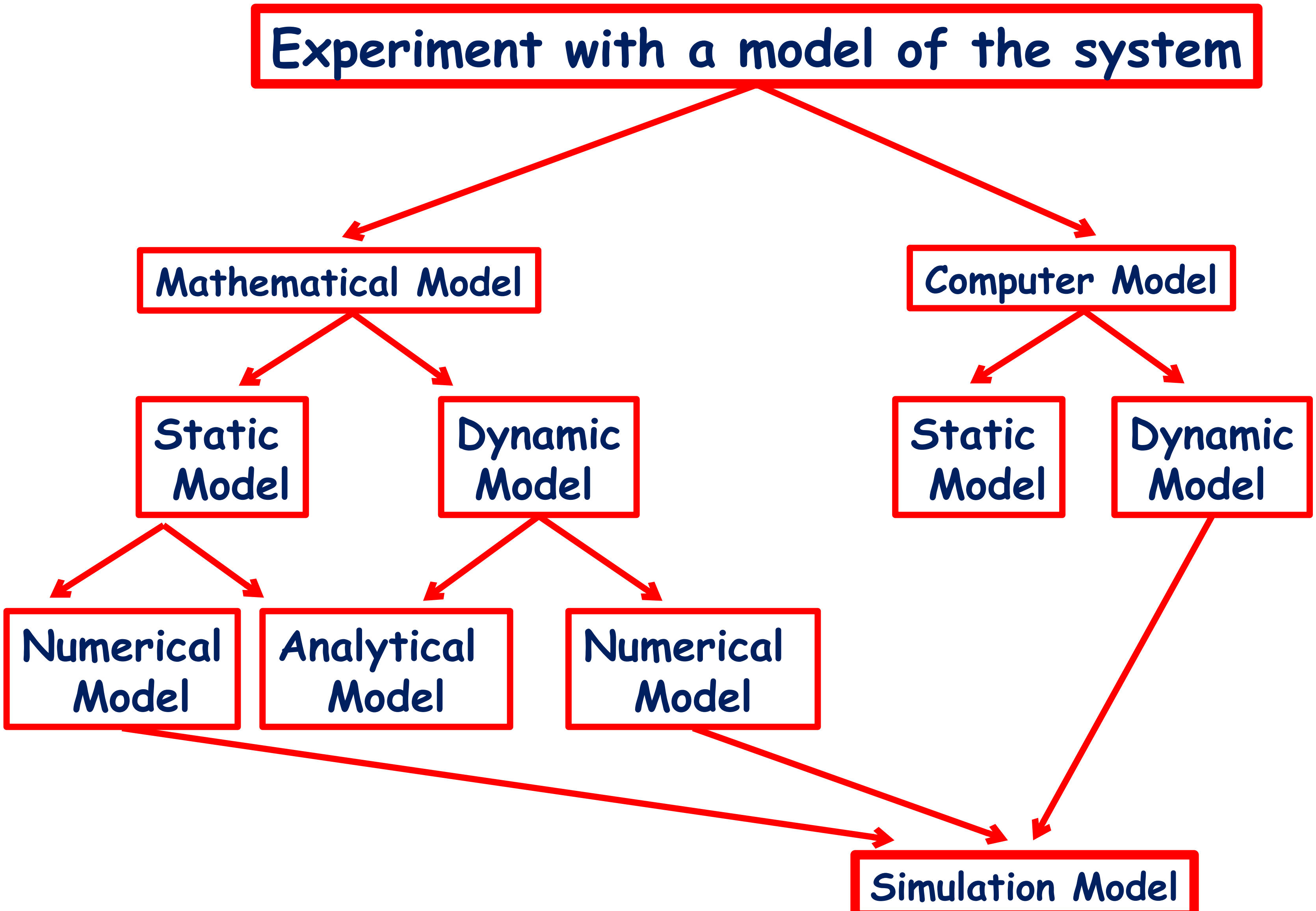
Simulation Models



Simulation Models

Simulation modeling

is the process of creating

and

analyzing

a digital prototype of a physical model

to predict its performance

in the real world.

Simulation Models

Simulation modeling

is used to help
designers and engineers understand
whether,
under what conditions,
and
in which ways
a part could fail
and
what loads it can withstand.

Simulation Models

Simulation Modeling

analyses the approximate working conditions

by applying the simulation software.

Analytical Vs. Numerical Vs. Simulation

Analytical solutions denote exact solutions

that can be used to study the behavior of the system with varying properties.

Unfortunately very few practical systems lead to analytical solutions, and analytical solutions are of limited use.

That's why we use numerical approach to make close answer to practical result.

Simulation : produces a huge amount of data that can statistically be reduced to your expectations .

Analytical Vs. Numerical Vs. Simulation

But just because this uses a lot of number crunching, it is not referred to as "numerical analysis".

Parts of it might rely on numerical methods that come from the approximation techniques of numerical analysis (as defined above), but this simulation is still not referred to as numerical analysis.

It could be called "performance prediction using modeling and simulation".

Mathematical Modeling Vs. Simulation

Translating the actual process behavior into mathematical expressions is mathematical modeling

and

solving that model with the help of a computer numerically is simulation.

Simulation Models Vs Analytical Models

Analytical Model is suitable when the model is simple.

For example, movement of body, we use calculus, algebra or probability theory.

Simulation model is suitable when the model is highly complex.

For example, Weather forecasting.

Simulation is not used when a suitable Analytical model exists.

Simulations are often complex error-prone pieces of software.

Simulation only produce approximate answers.

Simulation can take a LONG time to execute.

Models Taxonomy

Too costly or disruptive

Not appropriate for the design

There is always the question of whether it actually reflects the system.

SYSTEM

Experiment with the Actual System

Experiment with a Model of the System

Make assumptions that take the form of mathematical or logical relationships

Physical Model

Mathematical Model

Analytical Solution

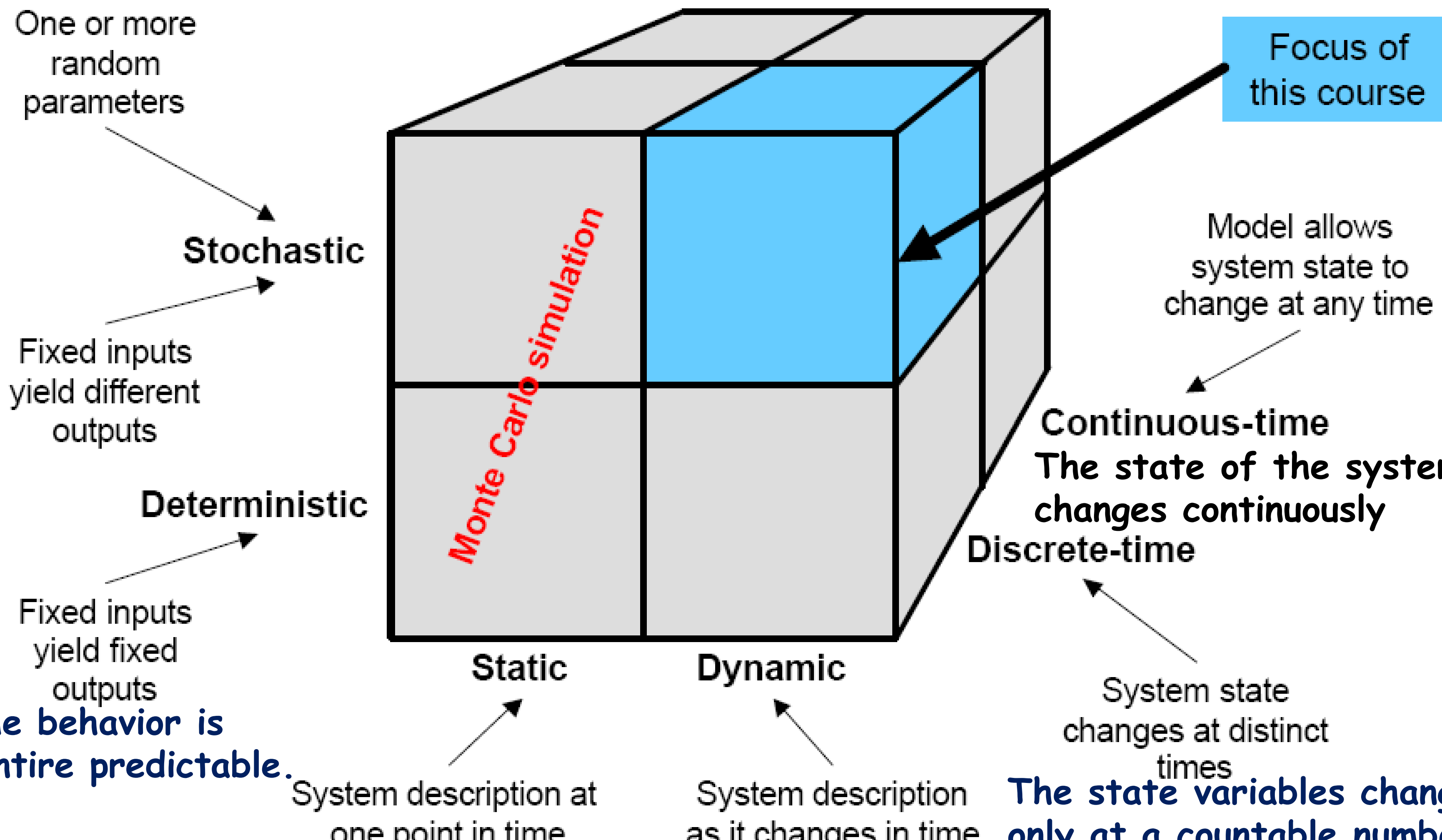
Simulation

If the model is simple enough.e.g., movement of a body calculus, algebra, probability theory

If the model is Highly complex systems, e.g. Weather forecasting

Types of Simulation Models

The behavior cannot be entirely predicted



The state of the system changes continuously

The behavior is entire predictable.

Snapshot at a single point in time

State variables change over time

The state variables change only at a countable number of points in time.