Overview

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What is a Mathematical Model?

A **mathematical model** is a mathematical representation of a system used to make predictions and provide insight about a real-world scenario, and **mathematical modelling** is the process of constructing, simulating and evaluating mathematical models.

Why do we construct mathematical models? It can often be costly (or impossible!) to conduct experiments to study a real-world problem and so a mathematical model is a way to describe the behaviour of a system and **predict outcomes** using **mathematical equations** and **computer simulations**.

> **See also**
>
> Check out the following resources to get started with mathematical modelling:
>
> - *Chapter 1: What is Mathematical Modelling?* in Principles of Mathematical Modeling
> - What is Math Modeling?
> - Wikipedia: Mathematical Model

Outline of the Modelling Process

Mathematical modelling involves observing some real-world phenomenon and formulating a mathematical representation of the system. But how do we even know where to start? Or how to find a solution? The **modelling process** is a systematic approach:

1. Clearly state the problem
2. Identify variables and parameters
3. Make assumptions and identify constraints
4. Build solutions
5. Analyze and assess
6. Report the results

Models can have a wide range of **complexity**! More complex does not necessarily mean better and we can sometimes work with more simplistic models to achieve good results. In many instances, we often start with a simple model and then build-up the complexity by **iterating** through the steps in modelling process until the model accurately describes the real-world application.

> **See also**
>
> Check out Math Modeling: Getting Started and Getting Solutions to read more about the modelling process.

Types of Models

There are *many* different types of mathematical models! In this course we focus on the following:

Deterministic models predict future based on current information and do not include randomness. These kinds of models often take the from of **systems of differential equations** which describe the evolution of a system over time.

Stochastic models include randomness and are based on **probability distributions** and **stochastic processes**.

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Data-driven models look for patterns in observed data to predict the output of a system. These kinds of models often take the form of **functions with parameters** computed to fit observed data.