Week 10 - Putting it all together

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- Describe and apply the entire mathematical modelling process

Introduction:

Welcome to this comprehensive lecture on the entire mathematical modeling process. Mathematical modeling is a systematic approach to understanding, analyzing, and solving complex real-world problems using mathematical techniques. In this lecture, we will cover the key stages and steps involved in the mathematical modeling process. Stage 1: Problem Formulation:

The mathematical modeling process begins with identifying and defining a real-world problem that can be addressed using mathematics. Key components of problem formulation include: Clearly stating the problem. Identifying the relevant variables and parameters. Establishing assumptions and constraints. Defining the goals and objectives of the modeling effort. Stage 2: Mathematical Representation:

Once the problem is formulated, mathematical equations, models, or algorithms are chosen to represent the system or phenomenon being studied. Selection of the appropriate mathematical framework depends on the nature of the problem: Differential equations for dynamic systems. Algebraic equations for steady-state problems. Statistical models for data-driven analysis. Optimization models for decision-making. Stage 3: Parameter Estimation:

Model parameters, which are often unknown, need to be estimated based on data or expert knowledge. Parameter estimation techniques may include statistical methods, optimization algorithms, or calibration processes. Accurate parameter values are crucial for the model's validity and reliability. Stage 4: Model Validation:

Model validation involves comparing the predictions of the mathematical model to real-world observations or experimental data. Various validation techniques, such as goodness-of-fit tests, cross-validation, and sensitivity analysis, are used to assess the model's accuracy and reliability. Model validation helps ensure that the model accurately represents the real system. Stage 5: Simulation and Analysis:

With a validated model, simulations are performed to study the system's behavior under various conditions and scenarios. Data generated from simulations are analyzed to gain insights into system dynamics, trends, and performance. Sensitivity analysis can be conducted to

understand the impact of parameter variations on model outcomes. Stage 6: Interpretation and Decision-Making:

Interpretation involves drawing meaningful conclusions from the modeling results. Model insights guide decision-making processes and help solve the original problem. Stakeholders and decision-makers are presented with findings, recommendations, and implications. Stage 7: Communication:

Effective communication of modeling results is essential for conveying insights to a wider audience. Reports, presentations, visualizations, and documentation are used to communicate findings and facilitate understanding. Clear communication ensures that the modeling results are actionable. Iterative Nature of Modeling:

It's important to note that mathematical modeling is often an iterative process: Models may need to be refined or adjusted based on validation results. New data or information may require updates to the model. Additional complexities or factors may need to be incorporated as the understanding of the problem deepens. Tools and Software:

Mathematical modeling often involves the use of specialized software tools, programming languages (e.g., MATLAB, Python), and computational resources. These tools assist in solving complex mathematical equations, conducting simulations, and analyzing data. Conclusion:

The mathematical modeling process is a systematic and rigorous approach to solving real-world problems using mathematical techniques. It involves stages of problem formulation, mathematical representation, parameter estimation, model validation, simulation, interpretation, communication, and often iterative refinements. Mathematical modeling is a powerful tool with applications in various fields, including science, engineering, economics, biology, and social sciences. Q&A Session:

Please feel free to ask any questions related to the mathematical modeling process.

Theoretical Questions

Practical Questions

To complete for Week 11

- ☐ Install R
- ☐ Install R Studio
- ☐ Install the following libraries
- ☐ Create a R Markdown File
- ☐ Save your R Markdown File as a pdf