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SOLICITATIONS OF MATHEMATICAL MODELING IN TECHNICAL AND NON-TECHNICAL REGIONS

Dr. Gurusharan Kaur
Department of Applied Sciences
Sagar Institute of Research and Technology, Bhopal

Aafiya Ansari
Department of CSIT
Sagar Institute of Research and Technology, Bhopal

Abstract

Mathematical models are used in applied mathematics in conjunction with engineering disciplines (computer science, electrical engineering) and natural sciences (physics, biology, earth science, and chemistry). Using mathematical modeling is a crucial for comprehending and resolving complex real-world issues. It entails utilizing mathematical terminology and ideas to theoretically model systems in order to study, forecast, and interpret their behavior. Mathematical modeling has many uses, ranging from managing pandemics to space exploration, which highlights its vital role in knowledge advancement and solving pressing global issues.

Keywords: Modeling, Analytics, Real-world problems, Prediction of Behavior

Introduction

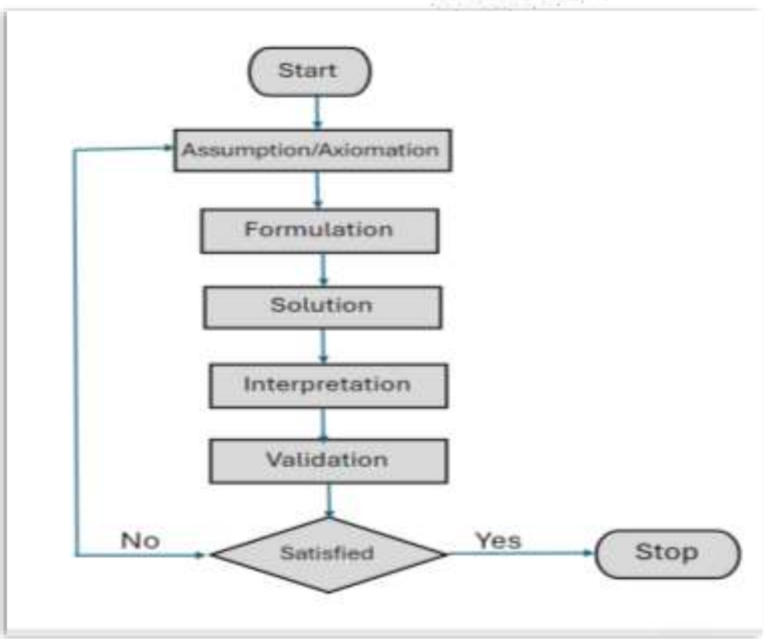
Representative models with mathematical images in them are called mathematical models. A mathematical model is a condensed illustration of a structure that utilizes terminology and concepts from mathematics. Creating a mathematical framework is known as mathematical programming. The process of modeling can be divided into four helpful categories: building, studying, testing, and usage. Abandons discovered during the considering and testing phases are typically fixed by returning to the structure stage. The circumstances that build up the test of interest are applied, and the mathematical model addresses the real model in virtual structure. The simulation starts, meaning that the PC determines the effects of those conditions on the mathematical model and produces an outcome that, depending on how it is executed, is either machine- or understandable-based. Generally speaking, numerical demonstrating is the process of creating or constructing numerical objects (such as a conditional arrangement, an arbitrary cycle, a mathematical or arithmetical design, a computation, or numbers) whose characteristics occasionally correspond to a particular real-world framework [1].

Despite their apparent commonality, the terms "model" and "modeling" actually refer to distinct ideas. Modeling is a process, whereas a model is a product that is created as a result of modeling. A mathematical model is a representation of the key elements of a particular situation in mathematical form, such as a formula, equation, graph, or table; mathematical modeling, on the other hand, is the process of creating a mathematical model [4].

Objectives of Mathematical Modeling

We can benefit from mathematical modeling in a number of ways. It is employed in the mathematical description and comprehension of a wide range of phenomena, including social, economic, and physical systems. It enables students to apply mathematical ideas to actual circumstances, encouraging critical thinking and greater comprehension. Another essential tool for sustainable development is mathematical modeling, which aids in the understanding, forecasting, and management of intricate processes. Additionally, it is a significant hands-on exercise that applies mathematical knowledge to address real-world problems. Incorporating mathematical modeling into instruction improves students' overall practical proficiency and their capacity for self-directed learning. In general, mathematical modeling aims to foster critical thinking, assist sustainable development, and offer a framework for analyzing and resolving issues in a variety of domains [1][3].

Steps in Mathematical Modeling



By definition, a mathematical model has assumptions and approximations because it is a reduced depiction of a genuine situation. The most crucial concern is, of course, whether our model works well or not—that is, if the model provides plausible answers when the results are physically understood. When a model's accuracy is insufficient, we look for the reasons why. It is possible that we will require a new evaluation in order to require a new formulation and mathematical manipulation.

Types of Modeling

There are various categories for mathematical models.

a) Linear versus Non-Linear: A mathematical model is considered linear if every operator in it exhibits linearity. If not, a model is nonlinear.
b) Static and Dynamic: A static (or steady-state) model computes the system in equilibrium and is therefore time-invariant, whereas a dynamic model takes into account time-dependent changes in the system's state.
c) Discrete and Continuous: Whereas a continuous model depicts the objects in a continuous fashion, a discrete model considers the items as discrete, such as the states in a statistical model or the particles in a molecular model.
d) Deterministic and Probabilistic: In a deterministic model, each set of variable states is exclusively defined by the model's parameters as well as by sets of the variables' prior states. Randomness exists in statistical models, and probability distributions rather than unique values are used to characterize variable states.
e) Strategic versus non-strategic: Players are shown in strategic models as independent decision-makers who logically select courses of action that optimize their goal function [6].

Application of Mathematical Modeling

Because mathematical modeling may be used to build models and find solutions to real-world issues, it has a wide and significant role. It finds application in diverse fields such as engineering, building, biology, and research, to mention a few. Applications of Mathematical Models focuses on applying logarithmic, mathematical, measurement, and likelihood concepts to real-world situations in sociology, science, individual accounting, and handicraft.

Among its many applications are the following, to mention a few[3]:

a) Skull modeling, arrangement, and annotation using anthropology.
b) Artificial intelligence applied to sophisticated robotics and mechanics.
c) It is utilized in the biological sciences to predict population dynamics, the spread of infectious illnesses, and the construction of genomic structures.

d) Atomic and molecular modeling employs it.
e) In economics for research on labor information.
f) Simulation of flying using space sciences.

Despite having a wide range of applications in numerous fields, mathematical modeling was essential in the 2020 Covid-19 pandemic to forecast the dynamics of transmission, future scenarios, and the behavior of the virus's spread under numerous assumptions, such as vaccination and isolated case consideration [5].

Benefits of mathematical modeling

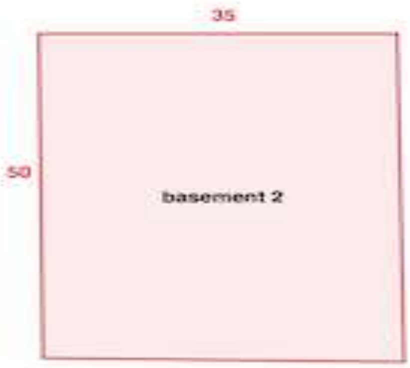
a) They are quick and easy to make.
b) They function in more uncertain situations. They can help us understand this current world better because certain things can be quickly altered.
c) A model has flaws that are not immediately apparent, and after testing, the disappointment's personality may shed light on the model's shortcomings.
d) Models gain from time since they may typically obtain findings in a short amount of time [3].

Limitations of Mathematical Modeling

a) A distorted model could unintentionally replicate the current state of reality.
b) The yield from the model will be inaccurate if the person who created it makes even the slightest error.
c) When compared to their typical client return, models can occasionally appear to be too expensive to even consider starting [3].

Examples of Mathematical Modeling

Example 1. A real estate agent has a very picky client who wants a very large basement. This client is so demanding that unless the basement is exactly 1750 sq. feet. He absolutely will not buy the house. Use Figure and help the poor agent pick which house has a basement that will work.



Solution- In the above question, dimensions of two basements are given for the client and he wants the basement of large area of exactly 1750 sq. Feet. Now, to sell the house the agent has to calculate the area of the basements to offer the client an appropriate house. For calculating the area, the agent has to know the dimensions and analyze the shape of the basement whose area has to be calculated (area of basement is rectangle).

The area calculation formula for Rectangle is,

$$\boxed{\text{Area} = \text{length} * \text{breadth}}$$

As we know the length and breadth, we can calculate the areas of both the basements

Area of Basement 1:

Length= 55
Breadth= 25
Now, area= 55*25
=1375 sq. Feet

Area of Basement 2:

Length= 50
Breadth= 35
Now, area=50*35
=1750sq. Feet

From the above results we can clearly say that area of basement 2 is exactly the same as the requirement of the client. So, the agent will definitely sell him the house with basement 2.

Example 2. A government wants to predict the population growth of a city over the next 20 years to plan for infrastructure, healthcare, and educational services. The current population is 500,000, and the carrying capacity (the maximum population that the environment can sustain indefinitely) is estimated to be 1,000,000. The current annual growth rate is 2.5%.

Solution- The logistic growth model is used to describe how a population grows in an environment with limited resources. It is represented by the following differential equation:

$$\frac{dP}{dt} = rP\left(1 - \frac{P}{K}\right)$$

P: Population size at time t.

r: Intrinsic growth rate.

K: Carrying capacity.

We need to solve the logistic differential equation to predict the population size over time. The solution to the logistic growth equation can be expressed as:

$$P(t) = \frac{K}{1 + \left(\frac{K - P_0}{P_0}\right) e^{-rt}}$$

where P_0 is the initial population size.

For this question,

Initial Population P(0)= 500,000

Carrying capacity K= 1,000,000

Growth rate r= 2.5% = 0.025

Now,

$$P(t) = \frac{1,000,000}{1 + \left(\frac{1,000,000 - 500,000}{500,000}\right) e^{-0.025t}}$$

for t = 20

$$P(20) = \frac{1,000,000}{1 + 1 \cdot e^{-0.5}} \approx 786,627$$

The predicted population sizes over the next 20 years indicate that the population will grow but will start to slow down as it approaches the carrying capacity of 1,000,000. This insight helps policymakers understand how quickly the population will grow and when it will start to level off, which is crucial for planning resources and services.

Conclusions

In conclusion, mathematical modeling is an important part of scientific research that allows for more accurate predictions about the physical world around us. With these tools at our disposal, we have access to incredible possibilities that could help shape our future in ways never before imagined. As technology advances so too does the complexity of our mathematical models allowing us to better understand the complexities of nature with ever increasing accuracy.

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