13. The Logistic Differential Equation

Suppose that P(t) describes the quantity of a population at time t. For example, P(t) could be the number of milligrams of bacteria in a particular beaker for a biology experiment, or P(t) could be the number of people in a particular country at a time t. A model of population growth tells plausible rules for how such a population changes over time. The simplest model of population growth is the **exponential model**, which assumes that there is a constant parameter r, called the **growth parameter**, such that

P'(t) = r P(t)

holds for all time t. This differential equation itself might be called the **exponential differential equation**, because its solution is

P(t) = P0 e^rt

where P0 = P(0) is the initial population.

One noticeable feature of the exponential model is that, when r is positive, the population always grows larger and larger without any finite limit, as is seen in Figure 1. This kind of growth may be a good model for a new population of bacteria in a beaker, but it does not hold for a long time. It is easy to see that the equation would imply a population of bacteria that ultimately outgrew the beaker and even outgrew the planet earth, since the mass of the bacteria would ultimately exceed the mass of the earth. Such a model is therefore absurd to model a system for long periods of time. The fundamental difficulty is that the exponential differential equation ignores the fact that there are limits to resources needed for the population to grow. It ignores the needs for food, oxygen, and space; and it ignores the accumulation of waste products that inevitably arise.
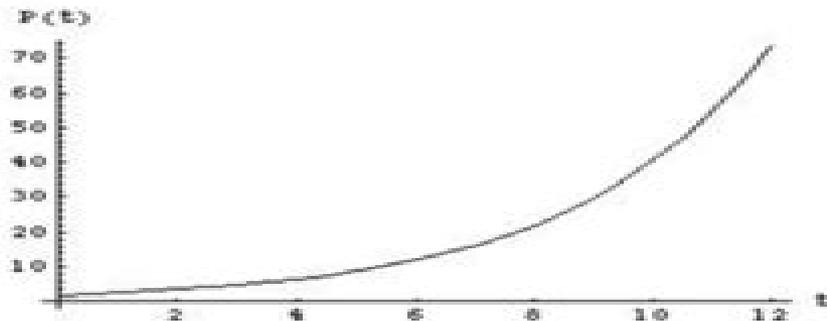

Figure 1 : P(t) = 2 e^{0.3t}. This example of the exponential model shows a population growing always faster without any bound.

An alternative model was proposed by Verhulst in 1836 to allow for the fact that there are limits to growth in all known biological systems. He proposed what is now called the **logistic differential equation**. The equation involves two positive parameters. The first parameter r is again called the **growth parameter** and plays a role similar to that of r in the exponential differential equation. The second parameter K is called the **carrying capacity**. The logistic differential equation is written

P'(t) = r P(t) [1 − P(t)/K].

Equivalently, in terms of the d notation, the logistic differential equation is

dP/dt = r P [1 − P / K]

13 The Logistic Differential Equation

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13 The Logistic Differential Equation:

Calculus R. A. Rosenbaum,G. P. Johnson,1984-02-24 Here is a textbook of intuitive calculus The material is presented in a concrete setting with many examples and problems chosen from the social physical behavioural and life sciences Chapters include core material and more advanced optional sections The book begins with a review of algebra and graphing

Elements of Mathematical Ecology Mark Kot,2001-07-19 Elements of Mathematical Ecology provides an introduction to classical and modern mathematical models methods and issues in population ecology The first part of the book is devoted to simple unstructured population models that ignore much of the variability found in natural populations for the sake of tractability Topics covered include density dependence bifurcations demographic stochasticity time delays population interactions predation competition and mutualism and the application of optimal control theory to the management of renewable resources The second part of this book is devoted to structured population models covering spatially structured population models with a focus on reaction diffusion models age structured models and two sex models Suitable for upper level students and beginning researchers in ecology mathematical biology and applied mathematics the volume includes numerous clear line diagrams that clarify the mathematics relevant problems thoughout the text that aid understanding and supplementary mathematical and historical material that enrich the main text   Computational Mathematics and Applications Dia Zeidan,Seshadev Padhi,Aliaa Burqan,Peer Ueberholz,2020-11-23 This book is a collection of invited and reviewed chapters on state of the art developments in interdisciplinary mathematics The book discusses recent developments in the fields of theoretical and applied mathematics covering areas of interest to mathematicians scientists engineers industrialists researchers faculty and students Readers will be exposed to topics chosen from a wide range of areas including differential equations integral reforms operational calculus numerical analysis fluid mechanics and computer science The aim of the book is to provide brief and reliably expressed research topics that will enable those new or not aware of mathematical sciences in this part of the world While the book has not been precisely planned to address any branch of mathematics it presents contributions of the relevant topics to do so The topics chosen for the book are those that we have found of significant interest to many researchers in the world These also are topics that are applicable in many fields of computational and applied mathematics This book constitutes the first attempt in Jordanian literature to scientifically consider the extensive need of research development at the national and international levels with which mathematics deals The book grew not only from the international collaboration between the authors but rather from the long need for a research based book from different parts of the world for researchers and professionals working in computational and applied mathematics This is the modified version of the back cover content on the print book   Mathematical Modeling in Discovery and Analysis of Immune Responses Jaroslaw Smieja,Penelope Anne Morel ,Urszula Foryś,2026-01-22 Uncovering mechanisms regulating immune system responses is key to strengthening and redirecting them whenever necessary in cancer and infections as well

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that can often be described in quantitative terms The second is that I have chosen topics that I believe are essential for a strategic sense of how to plan for execute and respond to technological change These two themes complement each other because the strategic sense requires an appreciation of the dynamics and the dynamics naturally lead to a consideration of how to deal with technology so that it can be used to achieve human objectives The unifying thought behind the book is that technological change has a systemic as well as an idiosyncratic aspect   Modeling and Simulation ,1986   Ordinary and Delay Differential Equations Joseph Wiener,1992-10-12 Reflects the contemporary achievements and problems in the theory and applications of ordinary and delay differential equations summarises recent results and methods and emphasises new ideas and directions for future research and activity   **U.S. Government Research & Development Reports** ,1970
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