

## VI. — ÉQUATIONS DIFFÉRENTIELLES

Les lois de la physique et donc celles de la mécanique se traduisent le plus souvent par des équations reliant des fonctions dépendant d'une ou plusieurs variables à leurs dérivées première et seconde par rapport à ces variables. Ces équations sont appelées des *équations différentielles*. Parmi elles, celles qui sont linéaires jouent un rôle important en raison de leur simplicité.

### VI.1. — Équations différentielles linéaires

Les équations différentielles que l'on rencontre le plus souvent dans les problèmes simples de mécanique sont *linéaires*, c'est-à-dire que toute combinaison linéaire de solutions est encore solution de l'équation. C'est le cas pour les équations suivantes, respectivement du premier et du deuxième ordre :

$$\frac{dV}{dt} + \frac{V}{\tau} = 0 \quad \text{et} \quad \frac{d^2X}{dt^2} + \frac{1}{\tau} \frac{dX}{dt} + c_a X = 0$$

$\tau$  et  $c_a$  étant des constantes. Les expressions ci-dessus sont linéaires par rapport aux fonctions  $V$ ,  $X$  et leurs dérivées.

**Remarque :** Si  $V$  a les dimensions d'une vitesse et si  $t$  représente le temps,  $\tau$  est homogène à une durée. Si  $X$  a la dimension d'une longueur,  $c_a$  est homogène à l'inverse d'une durée au carré.

Ces deux équations différentielles peuvent se ramener aisément à des équations avec second membre, dites *non homogène*. En effet, posant  $v = V + a\tau$  et  $x = X + b/c_a$ , on obtient respectivement :

$$\frac{dv}{dt} + \frac{v}{\tau} = a \quad \text{et} \quad \frac{d^2x}{dt^2} + \frac{1}{\tau} \frac{dx}{dt} + c_a x = b$$

Il suffit donc de résoudre les équations sans second membre précédentes (en  $V$  et en  $X$ ) et d'ajouter les solutions particulières suivantes :  $v = Cte = a\tau$  et  $x = Cte = b/c_a$  respectivement.

#### a) Équation différentielle du premier ordre

L'intégration de cette équation s'effectue sans difficulté. En effet, cherchons une solution de la forme  $Cte \times \exp(rt)$ . L'équation différentielle :

$$\frac{dv}{dt} + \frac{v}{\tau} = 0 \quad \text{donne} \quad \left(r + \frac{1}{\tau}\right) \exp(rt) = 0$$

d'où l'équation caractéristique  $r + 1/\tau = 0$ . On en déduit :

$$V = Cte \times \exp\left(-\frac{t}{\tau}\right) \quad \text{et} \quad v = Cte \times \exp\left(-\frac{t}{\tau}\right) + a\tau$$

Pour calculer la constante, il suffit de connaître  $v$  à un instant particulier. Par exemple, si, pour  $t = 0$ ,  $v = v_0$ , alors (Fig. A1.5) :

$$v = (v_0 - a\tau) \exp\left(-\frac{t}{\tau}\right) + a\tau$$



FIG. A1.5.

# Perio In Nonlin Diff Equa

**Mustafa R.S. Kulenovic, G. Ladas**



## **Periodicities in Nonlinear Difference Equations**

*Periodicities in Nonlinear Difference Equations* E.A. Grove, G. Ladas, 2004-12-16 Sharkovskiy's Theorem and Li and Yorke's period three implies chaos result and the  $3x+1$  conjecture are beautiful and deep results that demonstrate the rich periodic character of first order nonlinear difference equations To date however we still know surprisingly little about higher order nonlinear difference equations During the last ten years the authors of this book have been fascinated with discovering periodicities in equations of higher order which for certain values of their parameters have one of the following characteristics 1 Every solution of the equation is periodic with the same period 2 Every solution of the equation is eventually periodic with a prescribed period 3 Every solution of the equation converges to a periodic solution with the same period This monograph presents their findings along with some thought provoking questions and many open problems and conjectures worthy of investigation The authors also propose investigation of the global character of solutions of these equations for other values of their parameters and working toward a more complete picture of the global behavior of their solutions With the results and discussions it presents *Periodicities in Nonlinear Difference Equations* places a few more stones in the foundation of the basic theory of nonlinear difference equations Researchers and graduate students working in difference equations and discrete dynamical systems will find much to intrigue them and inspire further work in this area Difference Equations For Scientists And Engineering: Interdisciplinary Difference Equations

Michael A Radin, 2019-09-24 Radlin has done a nice job in producing a textbook which provides a learner friendly introduction to difference equations It would suit as a core text for a first year course in the topic aimed as the title suggests at physical science or engineering undergraduates The student who is prepared to work through the book will get a good grounding in basic techniques and gain a feel for the possible behaviours of standard equations He will also be given some indication of the usefulness and potential complexity of discrete systems in modern science and engineering London Mathematical Society We introduce interdisciplinary research and get students and the audience familiarized with the difference equations solving them explicitly determining the long term behavior of solutions convergence boundedness and periodicity We help to develop intuition in analyzing convergence of solutions in terms of subsequences and analyzing patterns of periodic cycles Our book helps you learn applications in biology economics and business computer science and engineering **Difference Equations, Discrete Dynamical Systems and Applications**

Sorin Olaru, Jim Cushing, Saber Elaydi, René Lozi, 2024-03-01 This book presents contributions related to new research results presented at the 27th International Conference on Difference Equations and Applications ICDEA 2022 that was held at CentraleSupélec Université Paris Saclay France under the auspices of the International Society of Difference Equations ISDE July 18-22 2022 The book aims not only to disseminate these results but to foster further advances in the fields of difference equations and discrete dynamical systems Also included are applications to economic growth modeling population dynamics epidemic modeling game theory control systems and network analysis The target audience for

the book includes Ph D students researchers educators and practitioners in these fields

**Periodic Character and Patterns of Recursive Sequences** Michael A. Radin, 2019-02-11 This textbook on periodic character and patterns of recursive sequences focuses on discrete periodic patterns of first order second order and higher order difference equations Aimed toward advanced undergraduate students and graduate students who have taken a basic course in Calculus I and Discrete Mathematics this book serves as a core text for a course in Difference Equations and Discrete Dynamical Systems The text contains over 200 exercises to provide readers with a hands on experience working with the material the exercises include computations of specific examples and proofs of general results Readers will receive a first hand introduction to patterns of periodic cycles and patterns of transient terms with exercises for most sections of the text preparing them for significant research work in the area

**Dynamics of Second Order Rational Difference Equations** Mustafa R.S. Kulenovic, G. Ladas, 2001-07-30 This self contained monograph provides systematic instructive analysis of second order rational difference equations After classifying the various types of these equations and introducing some preliminary results the authors systematically investigate each equation for semicycles invariant intervals boundedness periodicity and global stability

*Differential and Difference Equations with Applications* Sandra Pinelas, John R. Graef, Stefan Hilger, Peter Kloeden, Christos Schinas, 2020-10-21 This edited volume gathers selected peer reviewed contributions presented at the fourth International Conference on Differential Markov models time scales non linear difference equations multi scale modeling and myriad applications

**Dynamics of Third-Order Rational Difference Equations with Open Problems and Conjectures** Elias Camouzis, G. Ladas, 2007-11-16 Extending and generalizing the results of rational equations Dynamics of Third Order Rational Difference Equations with Open Problems and Conjectures focuses on the boundedness nature of solutions the global stability of equilibrium points the periodic character of solutions and the convergence to periodic solutions including their p

**Introduction to Differential Equations with Dynamical Systems** Stephen L. Campbell, Richard Haberman, 2011-10-14 Many textbooks on differential equations are written to be interesting to the teacher rather than the student Introduction to Differential Equations with Dynamical Systems is directed toward students This concise and up to date textbook addresses the challenges that undergraduate mathematics engineering and science students experience during a first course on differential equations And while covering all the standard parts of the subject the book emphasizes linear constant coefficient equations and applications including the topics essential to engineering students Stephen Campbell and Richard Haberman using carefully worded derivations elementary explanations and examples exercises and figures rather than theorems and proofs have written a book that makes learning and teaching differential equations easier and more relevant The book also presents elementary dynamical systems in a unique and flexible way that is suitable for all courses regardless of length

Mathematical Modelling with Differential Equations Ronald E. Mickens, 2022-05-23 Mathematical Modelling with Differential Equations aims to introduce various strategies for modelling

systems using differential equations Some of these methodologies are elementary and quite direct to comprehend and apply while others are complex in nature and require thoughtful deep contemplation Many topics discussed in the chapter do not appear in any of the standard textbooks and this provides users an opportunity to consider a more general set of interesting systems that can be modelled For example the book investigates the evolution of a toy universe discusses why alternate futures exists in classical physics constructs approximate solutions to the famous Thomas Fermi equation using only algebra and elementary calculus and examines the importance of truly nonlinear and oscillating systems Features Introduces defines and illustrates the concept of dynamic consistency as the foundation of modelling Can be used as the basis of an upper level undergraduate course on general procedures for mathematical modelling using differential equations Discusses the issue of dimensional analysis and continually demonstrates its value for both the construction and analysis of mathematical modelling

**Foundations of Ecology** Leslie A. Real, James H. Brown, 2012-12-20 Assembled here for the first time in one volume are forty classic papers that have laid the foundations of modern ecology Whether by posing new problems demonstrating important effects or stimulating new research these papers have made substantial contributions to an understanding of ecological processes and they continue to influence the field today The papers span nearly nine decades of ecological research from 1887 on and are organized in six sections foundational papers theoretical advances synthetic statements methodological developments field studies and ecological experiments Selections range from Connell's elegant account of experiments with barnacles to Watt's encyclopedic natural history from a visionary exposition by Grinnell of the concept of niche to a seminal essay by Hutchinson on diversity Six original essays by contemporary ecologists and a historian of ecology place the selections in context and discuss their continued relevance to current research This combination of classic papers and fresh commentaries makes *Foundations of Ecology* both a convenient reference to papers often cited today and an essential guide to the intellectual and conceptual roots of the field Published with the Ecological Society of America

*Mechanical Vibration* Haym Benaroya, Mark Nagurka, Seon Mi Han, 2022-07-15 The Fifth edition of this classic textbook includes a solutions manual Extensive supplemental instructor resources are forthcoming in the Fall of 2022 *Mechanical Vibration Theory and Application* presents comprehensive coverage of the fundamental principles of mechanical vibration including the theory of vibration as well as discussions and examples of the applications of these principles to practical engineering problems The book also addresses the effects of uncertainties in vibration analysis and design and develops passive and active methods for the control of vibration Many example problems with solutions are provided These examples as well as compelling case studies and stories of real world applications of mechanical vibration have been carefully chosen and presented to help the reader gain a thorough understanding of the subject There is a solutions manual for instructors who adopt this book Request a solutions manual here <https://www.rutgersuniversitypress.org/mechanical-vibration>

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new text designed for sophomores studying mathematics and computer science the authors cover the basics of difference equations and some of their applications in computing and in population biology Each chapter leads to techniques that can be applied by hand to small examples or programmed for larger problems Along the way the reader will use linear algebra and graph theory develop formal power series solve combinatorial problems visit Perron Frobenius theory discuss pseudorandom number generation and integer factorization and apply the Fast Fourier Transform to multiply polynomials quickly The book contains many worked examples and over 250 exercises While these exercises are accessible to students and have been class tested they also suggest further problems and possible research topics

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sometimes be quite theoretical sometimes intensely practical and often somewhere in between In this revision new author Douglas Meade focuses on developing students conceptual understanding with new concept questions and worksheets for each chapter Meade builds upon Boyce and DiPrima s work to combine a sound and accurate but not abstract exposition of the elementary theory of differential equations with considerable material on methods of solution analysis and approximation that have proved useful in a wide variety of applications The main prerequisite for engaging with the program is a working knowledge of calculus gained from a normal two or three semester course sequence or its equivalent Some familiarity with matrices will also be helpful in the chapters on systems of differential equations

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