

# INITIAL AND BOUNDARY VALUE PROBLEMS FOR PARTIAL FUNCTIONAL DIFFERENTIAL EQUATIONS

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(Received June, 1994; Revised August, 1996)

In this paper we study the existence of solutions to initial and boundary value problems of partial functional differential equations via a fixed-point analysis approach. Using the topological transversality theorem we derive conditions under which an initial or a boundary value problem has a solution.

**Key words:** Partial Functional Differential Equations, Initial Value Problems, Boundary Value Problems, Topological Transversality, *A Priori* Bounds.

**AMS subject classifications:** 35R10.

## 1. Introduction

In this paper we study initial and boundary value problems for a class of semilinear, abstract functional differential equations. This class is characterized by the fact that the associated homogeneous, linear differential equation generates a strongly continuous linear evolution system of compact operators.

More precisely, we consider the nonlinear Volterra integral equation

$$x(t) = W(t, \cdot)x(0) + \int_0^t W(t, s)f(s, x_s)ds, t \in [0, b] \quad (1.1)$$

together with an initial condition

$$x_0 = \varphi \quad (1.2)$$

or with a linear boundary condition

$$Lx = \alpha. \quad (1.3)$$

Our notations follow that of Hale [5] and Travis and Webb [12].  $X$  denotes a Banach space.  $C = C([-r, 0], X)$  is the Banach space of continuous  $X$ -valued functions with

# Boundary Value Problems For Functional Differential Equations

**Stephen Bancroft**



## **Boundary Value Problems For Functional Differential Equations:**

**Extrema of Nonlocal Functionals and Boundary Value Problems for Functional Differential Equations** Georgii Aleksandrovich Kamenskii, 2007 The non local functional is an integral with the integrand depending on the unknown function at different values of the argument These types of functionals have different applications in physics engineering and sciences The Euler type equations that arise as necessary conditions of extrema of non local functionals are the functional differential equations The book is dedicated to systematic study of variational calculus for non local functionals and to theory of boundary value problems for functional differential equations There are described different necessary and some sufficient conditions for extrema of non local functionals Theorems of existence and uniqueness of solutions to many kinds of boundary value problems for functional differential equations are proved The spaces of solutions to these problems are as a rule Sobolev spaces and it is not often possible to apply the analytical methods for solution of these problems Therefore it is important to have approximate methods for their solution Different approximate methods of solution of boundary value problems for functional differential equations and direct methods of variational calculus for non local functionals are described in the book The non local functional is an integral with the integrand depending on the unknown function at different values of the argument These types of functionals have different applications in physics engineering and sciences The Euler type equations that arise as necessary conditions of extrema of non local functionals are the functional differential equations The book is dedicated to systematic study of variational calculus for non local functionals and to theory of boundary value problems for functional differential equations There are described different necessary and some sufficient conditions for extrema of non local functionals Theorems of existence and uniqueness of solutions to many kinds of boundary value problems for functional differential equations are proved The spaces of solutions to these problems are as a rule Sobolev spaces and it is not often possible to apply the analytical methods for solution of these problems Therefore it is important to have approximate methods for their solution Different approximate methods of solution of boundary value problems for functional differential equations and direct methods of variational calculus for non local functionals are described in the book

**Boundary Value Problems for Functional Differential Equations** Johnny Henderson, 1995 Functional differential equations have received attention since the 1920 s Within that development boundary value problems have played a prominent role in both the theory and applications dating back to the 1960 s This book attempts to present some of the more recent developments from a cross section of views on boundary value problems for functional differential equations Contributions represent not only a flavor of classical results involving for example linear methods and oscillation nonoscillation techniques but also modern nonlinear methods for problems involving stability and control as well as cone theoretic degree theoretic and topological transversality strategies A balance with applications is provided through a number of papers dealing with a pendulum with dry friction heat conduction in a thin stretched resistance wire problems involving

singularities impulsive systems traveling waves climate modeling and economic control With the importance of boundary value problems for functional differential equations in applications it is not surprising that as new applications arise modifications are required for even the definitions of the basic equations This is the case for some of the papers contributed by the Perm seminar participants Also some contributions are devoted to delay Fredholm integral equations while a few papers deal with what might be termed as boundary value problems for delay difference equations

**Some Boundary Value Problems for First Order Scalar Functional Differential Equations** Robert Hakl, Alexander Lomtatidze, Jiří Šremr, 2002

Two-Point Boundary Value Problems: Lower and Upper Solutions C. De Coster, P. Habets, 2006-03-21 This book introduces the method of lower and upper solutions for ordinary differential equations This method is known to be both easy and powerful to solve second order boundary value problems Besides an extensive introduction to the method the first half of the book describes some recent and more involved results on this subject These concern the combined use of the method with degree theory with variational methods and positive operators The second half of the book concerns applications This part exemplifies the method and provides the reader with a fairly large introduction to the problematic of boundary value problems Although the book concerns mainly ordinary differential equations some attention is given to other settings such as partial differential equations or functional differential equations A detailed history of the problem is described in the introduction Presents the fundamental features of the method Construction of lower and upper solutions in problems Working applications and illustrated theorems by examples Description of the history of the method and Bibliographical notes

Boundary Value Problems for Systems of Differential, Difference and Fractional Equations Johnny Henderson, Rodica Luca, 2015-10-30 Boundary Value Problems for Systems of Differential Difference and Fractional Equations Positive Solutions discusses the concept of a differential equation that brings together a set of additional constraints called the boundary conditions As boundary value problems arise in several branches of math given the fact that any physical differential equation will have them this book will provide a timely presentation on the topic Problems involving the wave equation such as the determination of normal modes are often stated as boundary value problems To be useful in applications a boundary value problem should be well posed This means that given the input to the problem there exists a unique solution which depends continuously on the input Much theoretical work in the field of partial differential equations is devoted to proving that boundary value problems arising from scientific and engineering applications are in fact well posed Explains the systems of second order and higher orders differential equations with integral and multi point boundary conditions Discusses second order difference equations with multi point boundary conditions Introduces Riemann Liouville fractional differential equations with uncoupled and coupled integral boundary conditions

*Boundary-value Problems for Functional Differential Equations* Stephen Bancroft, 1968

Functional Differential Equations A. B. Antonevich, Andrei V Lebedev, m. Belousov, 1998-08-15 Together with the authors Volume I C Theory the two parts comprising Functional

Differential Equations II C Applications form a masterful work the first thorough up to date exposition of this field of modern analysis lying between differential equations and C algebras The two parts of Volume II contain the applications of the C structures and theory developed in Volume I They show the technique of using the C results in the study of the solvability conditions of non local functional differential equations and demonstrate the fundamental principles underlying the interrelations between C and functional differential objects The authors focus on non local pseudodifferential singular integral and Toeplitz operators with continuous and piecewise continuous coefficients convolution type operators with oscillating coefficients and shifts and operators associated with non local boundary value problems containing transformation operators of an argument on the boundary They build the symbolic calculus for all these classes of operators use it to treat concrete examples of non local operators present the explicit computation of their Fredholmity conditions and the index formulae and obtain a number of related results Part 1 Equations with Continuous Coefficients and Part 2 Equations with Discontinuous Coefficients and Boundary Value Problems can each stand alone and prove a valuable resource for researchers and students interested in operator algebraic methods in the theory of functional differential equations and to pure C algebraists looking for important and promising new applications Together these books form a powerful library for this intriguing field of modern analysis

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Ntouyas, Y.G. Sficas, P.Ch Tsamatos, 1991

**Some Boundary Value Problems for Functional Differential Equations**

Robert Emmett Fennell, 1969 *Boundary Value Problems for Functional Differential Equations with L2 Initial Functions* G.

W. Reddien, Glenn F. Webb, Vanderbilt University. Department of Mathematics, 1975

**Boundary Value Problems for**

**Systems of Linear Functional Differential Equations** Ivan Kiguradze, Bedřich Půža, 2003 **Boundary Value Problems by Matching and Functional Differential Equations** Rena Denise Taunton, 1995 *Boundary Value Problems For*

*Fractional Differential Equations And Systems* Bashir Ahmad, Johnny L Henderson, Rodica Luca, 2021-02-18 This book is devoted to the study of existence of solutions or positive solutions for various classes of Riemann Liouville and Caputo fractional differential equations and systems of fractional differential equations subject to nonlocal boundary conditions The monograph draws together many of the authors results that have been obtained and highly cited in the literature in the last four years In each chapter various examples are presented which support the main results The methods used in the proof of these theorems include results from the fixed point theory and fixed point index theory This volume can serve as a good resource for mathematical and scientific researchers and for graduate students in mathematics and science interested in the existence of solutions for fractional differential equations and systems

**Difference Approximations of Boundary Value Problems for Functional Differential Equations** G. W. Reddien, Vanderbilt University. Department of Mathematics, 1975

*Some Two-point Boundary Value Problems for Second Order Functional Differential Equations* Alexander

Lomtadze, Sul Khan Mukhigulashvili, 2000

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Belousov,1998-08-15 Together with the authors Volume I C Theory the two parts comprising Functional Differential Equations II C Applications form a masterful work the first thorough up to date exposition of this field of modern analysis lying between differential equations and C algebras The two parts of Volume II contain the applications of the C structures and theory developed in Volume I They show the technique of using the C results in the study of the solvability conditions of non local functional differential equations and demonstrate the fundamental principles underlying the interrelations between C and functional differential objects The authors focus on non local pseudodifferential singular integral and Toeplitz operators with continuous and piecewise continuous coefficients convolution type operators with oscillating coefficients and shifts and operators associated with non local boundary value problems containing transformation operators of an argument on the boundary They build the symbolic calculus for all these classes of operators use it to treat concrete examples of non local operators present the explicit computation of their Fredholmity conditions and the index formulae and obtain a number of related results Part 1 Equations with Continuous Coefficients and Part 2 Equations with Discontinuous Coefficients and Boundary Value Problems can each stand alone and prove a valuable resource for researchers and students interested in operator algebraic methods in the theory of functional differential equations and to pure C algebraists looking for important and promising new applications Together these books form a powerful library for this intriguing field of modern analysis

**Initial and Boundary Value Problems for Classes of Functional Differential Equations** Yun Gao,1998 **Elliptic Functional Differential Equations and Applications** Alexander L. Skubachevskii,1997-02-18 Boundary value problems for elliptic differential difference equations have some astonishing properties For example unlike elliptic differential equations the smoothness of the generalized solutions can be broken in a bounded domain and is preserved only in some subdomains The symbol of a self adjoint semibounded functional differential operator can change its sign The purpose of this book is to present for the first time general results concerning solvability and spectrum of these problems a priori estimates and smoothness of solutions The approach is based on the properties of elliptic operators and difference operators in Sobolev spaces The most important features distinguishing this work are applications to different fields of science The methods in this book are used to obtain new results regarding the solvability of nonlocal elliptic boundary value problems and the existence of Feller semigroups for multidimensional diffusion processes Moreover applications to control theory and aircraft and rocket technology are given The theory is illustrated with numerous figures and examples The book is addressed to graduate students and researchers in partial differential equations and functional differential equations It will also be of use to engineers in control theory and elasticity theory [Boundary Value Problems From Higher Order Differential Equations](#) Ravi P Agarwal,1986-07-01 Contents Some ExamplesLinear ProblemsGreen s FunctionMethod of Complementary FunctionsMethod of AdjointsMethod of ChasingSecond Order EquationsError Estimates in Polynomial InterpolationExistence and UniquenessPicard s and Approximate Picard s MethodQuasilinearization and Approximate QuasilinearizationBest

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