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Investigating Higher Order Boundary Value Problems on Time Scales

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Abstract

Higher-order boundary value problems on time scales provide a unified mathematical framework for studying differential and difference equations within a common setting. This paper investigates the existence and qualitative behaviour of solutions for higher-order boundary value problems formulated on arbitrary time scales, thereby encompassing both continuous and discrete cases. The study focuses on boundary conditions involving higher-order derivatives and examines the mathematical structures required to establish existence, uniqueness, positivity, and other relevant properties of solutions. By employing tools from time-scale calculus, fixed-point theory, Green's functions, and appropriate comparison techniques, sufficient conditions for the solvability of the proposed boundary value problems are developed. Particular attention is given to the way the underlying time scale influences the behaviour of solutions and the transition between differential and difference formulations. The framework provides a systematic approach for analysing problems that arise in mathematical models involving continuous, discrete, or hybrid phenomena. Several representative examples are considered to illustrate the applicability of the theoretical results and to demonstrate how the established conditions can be verified for specific classes of time scales. The results contribute to the broader theory of dynamic equations on time scales and provide useful insights into higher-order boundary value problems. The study also indicates potential applications in mathematical modelling, numerical analysis, control theory, and other areas where continuous and discrete processes occur simultaneously.

Keywords: Time Scales, Higher-Order Boundary Value Problems, Dynamic Equations, Time-Scale Calculus, Green's Functions, Fixed-Point Theory, Existence of Solutions, Uniqueness, Positive Solutions, Difference Equations.