

Article

Variational Estimation Methods for Sturm–Liouville Problems

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Abstract: In this paper, we are concerned with approach solutions for Sturm–Liouville problems (SLP) using variational problem (VP) formulation of regular SLP. The minimization problem (MP) is also set forth, and the connection between the solution of each formulation is then proved. Variational estimations (the variational equation associated through the Euler–Lagrange variational principle and Nehari’s method, shooting method and bisection method) and iterative variational methods (He’s method and HPM) for regular RSL are unitary presented in final part of the paper, which ends with applications.

Keywords: BVP nonlinear problems; variational methods; estimating nonlinearities; Green function

MSC: 34A12; 34A45



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1. Introduction

Nonlinearities are different from linear type by a function, an operator or a system that is nonlinear or is the case in which only some characteristics of it are known. The existence of the solution and the dependence of conditions for solving some classes of differential equations described by an operator is specified by the general framework of the Sturm–Liouville problem, with parametric conditions at the limit. The general framework of the Sturm–Liouville problem with parametric conditions at the limit is specified in the first part of the paper. The existence of the solution and the dependence of conditions is specified through the connection between the differential operator and Green’s function. Based on the properties of Green’s function, the operator used to analyze the behavior of the solution of the parameters given by the boundary conditions is specified. Variational problems derived from the initial RSLP are outlined with different type conditions in order to estimate the solution.

Let be the operator $L = -\frac{d}{dx} \left[p(x) \frac{d}{dx} \right] + q(x)$ as part of the regular Sturm–Liouville problem (RSL). The Sturm–Liouville (SL) problem expressed by the differential equation and the boundary conditions

$$a(x) \frac{d^2 u}{dx^2} + b(x) \frac{du}{dx} + c(x)u - \lambda d(x)u = 0, \quad (1)$$

$$\begin{aligned} B_1 : & \alpha_1 u(a) + \alpha_2 u'(a) = 0, \quad |\alpha_1| + |\alpha_2| \neq 0, \alpha_1, \alpha_2 \in \mathbb{R}, \\ B_2 : & \beta_1 u(b) + \beta_2 u'(b) = 0, \quad |\beta_1| + |\beta_2| \neq 0, \beta_1, \beta_2 \in \mathbb{R} \end{aligned} \quad (2)$$

could be written as

$$Lu + \lambda s(x)u = 0, \quad x \in (a, b) = I, \lambda \in \mathbb{R} \quad (3)$$

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Table of Contents Stable Methods For Illposed Variational Problems

1. Understanding the eBook Stable Methods For Illposed Variational Problems
 - The Rise of Digital Reading Stable Methods For Illposed Variational Problems
 - Advantages of eBooks Over Traditional Books
2. Identifying Stable Methods For Illposed Variational Problems
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Stable Methods For Illposed Variational Problems
 - User-Friendly Interface
4. Exploring eBook Recommendations from Stable Methods For Illposed Variational Problems
 - Personalized Recommendations
 - Stable Methods For Illposed Variational Problems User Reviews and Ratings
 - Stable Methods For Illposed Variational Problems and Bestseller Lists
5. Accessing Stable Methods For Illposed Variational Problems Free and Paid eBooks

- Stable Methods For Illposed Variational Problems Public Domain eBooks
 - Stable Methods For Illposed Variational Problems eBook Subscription Services
 - Stable Methods For Illposed Variational Problems Budget-Friendly Options
6. Navigating Stable Methods For Illposed Variational Problems eBook Formats
 - ePub, PDF, MOBI, and More
 - Stable Methods For Illposed Variational Problems Compatibility with Devices
 - Stable Methods For Illposed Variational Problems Enhanced eBook Features
 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Stable Methods For Illposed Variational Problems
 - Highlighting and Note-Taking Stable Methods For Illposed Variational Problems
 - Interactive Elements Stable Methods For Illposed Variational Problems
 8. Staying Engaged with Stable Methods For Illposed Variational Problems
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Stable Methods For Illposed Variational Problems
 9. Balancing eBooks and Physical Books Stable Methods For Illposed Variational Problems
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Stable Methods For Illposed Variational Problems
 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
 11. Cultivating a Reading Routine Stable Methods For Illposed Variational Problems
 - Setting Reading Goals Stable Methods For Illposed Variational Problems
 - Carving Out Dedicated Reading Time
 12. Sourcing Reliable Information of Stable Methods For Illposed Variational Problems
 - Fact-Checking eBook Content of Stable Methods For Illposed Variational Problems
 - Distinguishing Credible Sources
 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development

- Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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