

Robust numerical method for singularly perturbed differential equations having both large and small delay

Habtamu Garoma Debela

College of Natural Sciences, Jimma University, Jimma, Ethiopia

Robust
numerical
method

Received 7 September 2020
Revised 28 October 2020
Accepted 1 December 2020

Abstract

Purpose – The purpose of this study is to develop stable, convergent and accurate numerical method for solving singularly perturbed differential equations having both small and large delay.

Design/methodology/approach – This study introduces a fitted non-polynomial spline method for singularly perturbed differential equations having both small and large delay. The numerical scheme is developed on uniform mesh using fitted operator in the given differential equation.

Findings – The stability of the developed numerical method is established and its uniform convergence is proved. To validate the applicability of the method, one model problem is considered for numerical experimentation for different values of the perturbation parameter and mesh points.

Originality/value – In this paper, the authors consider a new governing problem having both small delay on convection term and large delay. As far as the researchers' knowledge is considered numerical solution of singularly perturbed boundary value problem containing both small delay and large delay is first being considered.

Keywords Singularly perturbed, Small delay, Large delay, Fitted spline, ϵ -uniformly convergent

Paper type Research paper

1. Introduction

A differential equation is said to be singularly perturbed delay differential equation, if it includes at least one delay term, involving unknown functions occurring with different arguments, and also, the highest derivative term is multiplied by a small parameter. Such type of delay, differential equations play a very important role in the mathematical models of science and engineering, such as the human pupil light reflex with mixed delay type [1], variational problems in control theory with small state problem [2], models of HIV infection [3] and signal transition [4].

Any system involving a feedback control almost involves time delay. The delay occurs because a finite time is required to sense the information and then react to it. Finding the solution of singularly perturbed delay differential equations, whose application mentioned above, is a challenging problem. In response to these, in recent years, there has been a growing interest in numerical methods on singularly perturbed delay differential equations. The

2010 MSC — 65L11, 65L12, 65L20

© Habtamu Garoma Debela. Published in *Arab Journal of Mathematical Sciences*. Published by Emerald Publishing Limited. This article is published under the Creative Commons Attribution (CC BY 4.0) licence. Anyone may reproduce, distribute, translate and create derivative works of this article (for both commercial and non-commercial purposes), subject to full attribution to the original publication and authors. The full terms of this licence may be seen at <http://creativecommons.org/licenses/by/4.0/legalcode>

The authors wish to express their thanks to Jimma University, College of Natural Sciences, for technical support and the authors of the literature for the provided scientific aspects and idea for this work.



Arab Journal of Mathematical
Sciences
Emerald Publishing Limited
e-ISSN: 2588-9214
p-ISSN: 1120-3288
DOI: 10.1108/AJMS-09-2020-0006

Singularly Perturbed Differential Equati

E.M. de Jager, J.F. Furu



Singularly Perturbed Differential Equati:

Decoding **Singularly Perturbed Differential Equati**: Revealing the Captivating Potential of Verbal Expression

In a period characterized by interconnectedness and an insatiable thirst for knowledge, the captivating potential of verbal expression has emerged as a formidable force. Its power to evoke sentiments, stimulate introspection, and incite profound transformations is genuinely awe-inspiring. Within the pages of "**Singularly Perturbed Differential Equati**," a mesmerizing literary creation penned by a celebrated wordsmith, readers embark on an enlightening odyssey, unraveling the intricate significance of language and its enduring affect our lives. In this appraisal, we shall explore the book is central themes, evaluate its distinctive writing style, and gauge its pervasive influence on the hearts and minds of its readership.

https://archive.kdd.org/About/book-search/default.aspx/the_fantastical_engineer_a_thrillseekers_guide_to_careers_in_theme_park_engineering.pdf

Table of Contents Singularly Perturbed Differential Equati

1. Understanding the eBook Singularly Perturbed Differential Equati
 - The Rise of Digital Reading Singularly Perturbed Differential Equati
 - Advantages of eBooks Over Traditional Books
2. Identifying Singularly Perturbed Differential Equati
 - 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 Singularly Perturbed Differential Equati
 - User-Friendly Interface
4. Exploring eBook Recommendations from Singularly Perturbed Differential Equati
 - Personalized Recommendations
 - Singularly Perturbed Differential Equati User Reviews and Ratings

-
- Singularly Perturbed Differential Equati and Bestseller Lists
5. Accessing Singularly Perturbed Differential Equati Free and Paid eBooks
 - Singularly Perturbed Differential Equati Public Domain eBooks
 - Singularly Perturbed Differential Equati eBook Subscription Services
 - Singularly Perturbed Differential Equati Budget-Friendly Options
 6. Navigating Singularly Perturbed Differential Equati eBook Formats
 - ePub, PDF, MOBI, and More
 - Singularly Perturbed Differential Equati Compatibility with Devices
 - Singularly Perturbed Differential Equati Enhanced eBook Features
 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Singularly Perturbed Differential Equati
 - Highlighting and Note-Taking Singularly Perturbed Differential Equati
 - Interactive Elements Singularly Perturbed Differential Equati
 8. Staying Engaged with Singularly Perturbed Differential Equati
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Singularly Perturbed Differential Equati
 9. Balancing eBooks and Physical Books Singularly Perturbed Differential Equati
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Singularly Perturbed Differential Equati
 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
 11. Cultivating a Reading Routine Singularly Perturbed Differential Equati
 - Setting Reading Goals Singularly Perturbed Differential Equati
 - Carving Out Dedicated Reading Time
 12. Sourcing Reliable Information of Singularly Perturbed Differential Equati
 - Fact-Checking eBook Content of Singularly Perturbed Differential Equati
 - 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

Singularly Perturbed Differential Equati Introduction

In this digital age, the convenience of accessing information at our fingertips has become a necessity. Whether its research papers, eBooks, or user manuals, PDF files have become the preferred format for sharing and reading documents. However, the cost associated with purchasing PDF files can sometimes be a barrier for many individuals and organizations. Thankfully, there are numerous websites and platforms that allow users to download free PDF files legally. In this article, we will explore some of the best platforms to download free PDFs. One of the most popular platforms to download free PDF files is Project Gutenberg. This online library offers over 60,000 free eBooks that are in the public domain. From classic literature to historical documents, Project Gutenberg provides a wide range of PDF files that can be downloaded and enjoyed on various devices. The website is user-friendly and allows users to search for specific titles or browse through different categories. Another reliable platform for downloading Singularly Perturbed Differential Equati free PDF files is Open Library. With its vast collection of over 1 million eBooks, Open Library has something for every reader. The website offers a seamless experience by providing options to borrow or download PDF files. Users simply need to create a free account to access this treasure trove of knowledge. Open Library also allows users to contribute by uploading and sharing their own PDF files, making it a collaborative platform for book enthusiasts. For those interested in academic resources, there are websites dedicated to providing free PDFs of research papers and scientific articles. One such website is Academia.edu, which allows researchers and scholars to share their work with a global audience. Users can download PDF files of research papers, theses, and dissertations covering a wide range of subjects. Academia.edu also provides a platform for discussions and networking within the academic community. When it comes to downloading Singularly Perturbed Differential Equati free PDF files of magazines, brochures, and catalogs, Issuu is a popular choice. This digital publishing platform hosts a vast collection of publications from around the world. Users can search for specific titles or explore various categories and genres. Issuu offers a seamless reading experience with its user-friendly interface and allows users to download PDF files for offline reading. Apart from dedicated platforms, search engines also play a crucial role in finding free PDF files. Google, for instance, has an advanced search feature that allows users to filter results by file type. By specifying the file type as "PDF,"

users can find websites that offer free PDF downloads on a specific topic. While downloading Singularly Perturbed Differential Equati free PDF files is convenient, its important to note that copyright laws must be respected. Always ensure that the PDF files you download are legally available for free. Many authors and publishers voluntarily provide free PDF versions of their work, but its essential to be cautious and verify the authenticity of the source before downloading Singularly Perturbed Differential Equati. In conclusion, the internet offers numerous platforms and websites that allow users to download free PDF files legally. Whether its classic literature, research papers, or magazines, there is something for everyone. The platforms mentioned in this article, such as Project Gutenberg, Open Library, Academia.edu, and Issuu, provide access to a vast collection of PDF files. However, users should always be cautious and verify the legality of the source before downloading Singularly Perturbed Differential Equati any PDF files. With these platforms, the world of PDF downloads is just a click away.

FAQs About Singularly Perturbed Differential Equati Books

1. Where can I buy Singularly Perturbed Differential Equati books? Bookstores: Physical bookstores like Barnes & Noble, Waterstones, and independent local stores. Online Retailers: Amazon, Book Depository, and various online bookstores offer a wide range of books in physical and digital formats.
2. What are the different book formats available? Hardcover: Sturdy and durable, usually more expensive. Paperback: Cheaper, lighter, and more portable than hardcovers. E-books: Digital books available for e-readers like Kindle or software like Apple Books, Kindle, and Google Play Books.
3. How do I choose a Singularly Perturbed Differential Equati book to read? Genres: Consider the genre you enjoy (fiction, non-fiction, mystery, sci-fi, etc.). Recommendations: Ask friends, join book clubs, or explore online reviews and recommendations. Author: If you like a particular author, you might enjoy more of their work.
4. How do I take care of Singularly Perturbed Differential Equati books? Storage: Keep them away from direct sunlight and in a dry environment. Handling: Avoid folding pages, use bookmarks, and handle them with clean hands. Cleaning: Gently dust the covers and pages occasionally.
5. Can I borrow books without buying them? Public Libraries: Local libraries offer a wide range of books for borrowing. Book Swaps: Community book exchanges or online platforms where people exchange books.
6. How can I track my reading progress or manage my book collection? Book Tracking Apps: Goodreads, LibraryThing, and Book Catalogue are popular apps for tracking your reading progress and managing book collections. Spreadsheets:

You can create your own spreadsheet to track books read, ratings, and other details.

7. What are Singularly Perturbed Differential Equati audiobooks, and where can I find them? Audiobooks: Audio recordings of books, perfect for listening while commuting or multitasking. Platforms: Audible, LibriVox, and Google Play Books offer a wide selection of audiobooks.
8. How do I support authors or the book industry? Buy Books: Purchase books from authors or independent bookstores. Reviews: Leave reviews on platforms like Goodreads or Amazon. Promotion: Share your favorite books on social media or recommend them to friends.
9. Are there book clubs or reading communities I can join? Local Clubs: Check for local book clubs in libraries or community centers. Online Communities: Platforms like Goodreads have virtual book clubs and discussion groups.
10. Can I read Singularly Perturbed Differential Equati books for free? Public Domain Books: Many classic books are available for free as theyre in the public domain. Free E-books: Some websites offer free e-books legally, like Project Gutenberg or Open Library.

Find Singularly Perturbed Differential Equati :

the fantastical engineer a thrillseekers guide to careers in theme park engineering

the fivesquare city; the city in the religious imagination.

the fighting illini

the feng shui kitchen the philosophers guide to cooking and eating isbn1885203934

the family welcome accomodation guide 1991

the first men the emergence of man series by the editors of time lifes

the fires of autumn sexual activity in the middle and later years

the fantod

the first year retirement journal

the first of the jungle

the fantom spider

the films of jack nicholson

the far side

the film year 1983 film review

the fishfly

Singularly Perturbed Differential Equati :

Realidades Practice Workbook 3 - 1st Edition - Solutions ... Our resource for Realidades Practice Workbook 3 includes answers to chapter exercises, as well as detailed information to walk you through the process step by ... Realidades 3 Chapter 3 Flashcards Vocabulary Only Learn with flashcards, games, and more — for free. Realidades 3 Chapter 3 Que haces para estar en forma? Unit Overview. In Chapter 3, students will be introduced to additional common vocabulary, phrases and concepts related to. Realidades 3 chapter 3 - Teaching resources Realidades 3 chapter 3 · Examples from our community · 10000+ results for 'realidades 3 chapter 3' · Can't find it? Just make your own! Realidades 3 - Capítulo 3 - Profesora Dowden A ver si recuerdas. Quizlet: https://quizlet.com/_49gxbi. Capítulo 3 Vocabulario. Parte 1 Quizlet: https://quizlet.com/_4a7sie Realidades 3 capitulo 3 Browse realidades 3 capitulo 3 resources on Teachers Pay Teachers, a marketplace trusted by millions of teachers for original educational resources. Realidades 3 cap 3 vocabulario - Teaching resources Realidades 3 cap 3 vocabulario · Examples from our community · 10000+ results for 'realidades 3 cap 3 vocabulario' · Can't find it? Just make your own! Realidades 3 Capítulo 3 Parte 1 y 2 - Vocabulary Realidades 3 Capítulo 3 Parte 1 y 2 · Open Input · Multiple Choice · Conjugation Drill. Realidades 3, Cap. 3 - Vocabulario Java Games: Flashcards, matching, concentration, and word search. Realidades ... Realidades (3 May 2, 2009 — Realidades (3. Nombre. Capitulo 3. Fecha. Ser consejero(a). Hora. 15. Core Practice 3-11. ¿Puedes ayudar a los estudiantes que tienen problemas ... Ashworth College Semester Exam Answer Sheet Please ... Ashworth College Semester Exam Answer Sheet Please return to Ashworth College from MANAGMENT 321 at Integral University. Ashworth Colege (Ashworth) Ashworth College students can get immediate homework help and access over 89000+ documents, study resources, practice tests, essays, notes and more. Ashworth College Semester Exam by Tutorsof Jan 23, 2023 — All exams are passed. So, you can simply use these answers without hesitation. Answer of Semester Exams of various subjects are listed below:. What Happens if You Fail an Exam? Oct 12, 2023 — For semester exams, the minimum passing score is 70%. If all sections aren't passed, you may retake the failed section once. The retake is 36 ... Ashworth College Exam homework help Search our homework answers. The answer you are looking for might already be there. Ashworth College Semester Examinations Jun 1, 2023 — Through this book, I aim to provide you with questions and reliable sources of answers that you can use in the exam. I am just a collector of ... Ashworth college semester exam answers: Fill out & sign ... Handling paperwork with our extensive and intuitive PDF editor is easy. Make the steps below to complete Ashworth proctor online quickly and easily:. Ashworth College Homework Help & Answers Get Ashworth College help — Post your Ashworth College homework questions and get answers from qualified tutors. · Ask a Question · TOP ASHWORTH COLLEGE QUESTIONS. How Do Proctored Exams Work? Feb 17, 2022 — A proctor exam is an online test overseen by a teacher, friend, or other approved proctor. Learn how to choose a proctor and how proctored ... Ashworth College Community: Message List Semester exams are proctored, timed, and scheduled at the convenience of the proctor and

student. Students may use their textbooks, printed course materials, ... 1974 Wiring schematics Apr 19, 2019 — Hi all, I'm searching for a clear and possibly coloured wiring schematics of my 1974 corvette. Do you have a link where to download or buy it? C3 1974 Corvette Wiring Diagram - PDF File C3 1974 Corvette Wiring Diagram - PDF File - Download Only. C3 Corvette Wiring Diagrams Jan 6, 2010 — If you're chasing an electrical problem and the circuit you're following runs from one page to another, print the diagrams as big as you can, ... 53-82 Wiring Diagrams - Forums Mar 16, 2023 — Ben(cthulhu) has generously offered to host these wiring diagrams, and the parts manuals on his site, so anyone can download them if ya want to. Download Free 1974 Corvette Wiring Diagrams Download Free 1974 Corvette Wiring. Diagrams. 1. Download Free 1974. Corvette Wiring. Diagrams. Download. Free. 1974. Corvette. Wiring. Diagrams. Downloaded. Wirinig Diagram Archives | Willcox Corvette, Inc. Jul 11, 2018 — 55 New Bobcat 743 Starter Wiring Diagram- Your starter went out and you desire to replace it: Here's what to do:First you obsession to acquire ... Chevrolet Vehicles Diagrams, Schematics, Service Manuals We have 191 Chevrolet Vehicles Diagrams, Schematics or Service Manuals to choose from, all free to download! PDF File icon 1923 chevrolet car wiring [846 KB] ... Chevrolet Corvette Service Repair Manuals | Free Download 2000-2001 Chevrolet Corvette Service Repair Manual + Wiring Diagram. C3 1976 Corvette Wiring Diagram - PDF File C3 1976 Corvette Wiring Diagram - PDF File - Download Only Larger Photo ... Seat Belt Warning Manual 1974. Our Low Price USD\$65.99. Add. corvette part 79 ...