

Review

Approximate Calculation of Functional Integrals Generated by Nonrelativistic and Relativistic Hamiltonians

Edik Ayryan ^{1,2,3}, Michal Hnatic ^{4,5,6,*}, Juha Honkonen ^{7,8}  and Victor Malyutin ⁹

¹ Meshcheryakov Laboratory of Information Technologies, Joint Institute for Nuclear Research, 141980 Dubna, Russia; ayryan@jinr.ru

² Institute of System Analysis and Management, Dubna State University, 141962 Dubna, Russia

³ A.I. Akhshunyan National Science Laboratory, Yerevan 0006, Armenia

⁴ Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, 141980 Dubna, Russia

⁵ Institute of Experimental Physics, Slovak Academy of Sciences, 04001 Košice, Slovakia

⁶ Faculty of Sciences, P.J. Šafárik University in Košice, 04001 Košice, Slovakia

⁷ Department of Military Technology, National Defence University, 00860 Helsinki, Finland;

juha.honkonen@helsinki.fi

⁸ Department of Physics, University of Helsinki, 00014 Helsinki, Finland

⁹ Institute of Mathematics of the National Academy of Sciences of Belarus, 220072 Minsk, Belarus;

malyutin@im.bas-net.by

* Correspondence: hnatic@saske.sk

Abstract: The discussion revolves around the most recent outcomes in the realm of approximating functional integrals through calculations. Review of works devoted to the application of functional integrals in quantum mechanics and quantum field theory, nuclear physics and in other areas is presented. Methods obtained by the authors for approximate calculation of functional integrals generated by nonrelativistic Hamiltonians are given. One of the methods is based on the expansion in eigenfunctions of the Hamiltonian. In an alternate approach, the functional integrals are tackled using the semiclassical approximation. Methods for approximate evaluation of functional integrals generated by relativistic Hamiltonians are presented. These are the methods using functional polynomial approximation (analogue of formulas of a given degree of accuracy) and methods based on the expansion in eigenfunctions of the Hamiltonian, generating a functional integral.

Keywords: functional integrals; nonrelativistic and relativistic Hamiltonians; Schrödinger-type equation; methods for approximate calculation of integrals



Citation: Ayryan, E.; Hnatic, M.; Honkonen, J.; Malyutin, V. Approximate Calculation of Functional Integrals Generated by Nonrelativistic and Relativistic Hamiltonians. *Symmetry* **2023**, *15*, 1785. <https://doi.org/10.3390/sym15091785>

Academic Editors: Vyacheslav Yakovlev, Rashid G. Nazmitdinov and V. S. Bagmatov

Received: 21 August 2023
Revised: 11 September 2023
Accepted: 15 September 2023
Published: 18 September 2023



Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Functional integrals are widely used in quantum mechanics and quantum field theory nuclear physics and in many other areas (see [1–11] and references therein). In particular, functional integrals are used in the description of quantum mechanical systems of particles with different Hamiltonians.

The wide application of functional integrals stimulates the development of methods for their approximate calculation. Significant progress has been made over the past half century in the field of approximate calculation of functional integrals.

The motivation for writing this article was the desire to review well-known existing methods and methods obtained by the authors in recent years for calculating functional integrals.

There are various methods for computing different types of functional integrals. Since the “Feynman measure” is not a measure in the mathematically strict sense, many different approaches to Feynman integrals have arisen, substantiating their construction and offering appropriate methods for their approximate calculation [12–15].

Among the methods used, we note the Monte Carlo method for the approximate calculation of functional integrals [16–18].

Functional Integrals Approximate Evaluations And Applications

L Reisser



Functional Integrals Approximate Evaluations And Applications:

Functional Integrals A.D. Egorov, P.I. Sobolevsky, L.A. Yanovich, 2012-12-06 Integration in infinitely dimensional spaces continual integration is a powerful mathematical tool which is widely used in a number of fields of modern mathematics such as analysis the theory of differential and integral equations probability theory and the theory of random processes This monograph is devoted to numerical approximation methods of continual integration A systematic description is given of the approximate computation methods of functional integrals on a wide class of measures including measures generated by homogeneous random processes with independent increments and Gaussian processes Many applications to problems which originate from analysis probability and quantum physics are presented This book will be of interest to mathematicians and physicists including specialists in computational mathematics functional and statistical physics nuclear physics and quantum optics

Frontiers of Fundamental Physics Burra Gautam Sidharth, A. Burinskii, 1999 These volume are an overview of the recent development in the challenging realm of the unification theory of Cosmology Quantum gravity Particle physics General relativity and Gravitation These volumes contain contributions from distinguished researchers worldwide Theoretical and experimental physicists and philosophers will find this book a valuable and essential resource

Monte Carlo and Quasi-Monte Carlo Methods 2010 Leszek Plaskota, Henryk Woźniakowski, 2012-08-23 This book represents the refereed proceedings of the Ninth International Conference on Monte Carlo and Quasi Monte Carlo Methods in Scientific Computing that was held at the University of Warsaw Poland in August 2010 These biennial conferences are major events for Monte Carlo and the premiere event for quasi Monte Carlo research The proceedings include articles based on invited lectures as well as carefully selected contributed papers on all theoretical aspects and applications of Monte Carlo and quasi Monte Carlo methods The reader will be provided with information on latest developments in these very active areas The book is an excellent reference for theoreticians and practitioners interested in solving high dimensional computational problems arising in particular in finance and statistics

Programming And Mathematical Techniques In Physics - Proceedings Of The Conference On Programming And Mathematical Methods For Solving Physical Problems Yu Yu Lobanov, E P Zhidkov, 1994-05-16 This volume is a collection of papers which were presented at the traditional international conference on programming and mathematical methods for solving physical problems The topics covered a wide scope of problems including information database systems networking data acquisition systems analytical and numerical methods for solution of the physical problems

Approximation Theory IX: Computational aspects C. K. Chui, Larry L. Schumaker, 1998 This meticulously edited selection of papers comes out of the Ninth International Symposium on Approximation Theory held in Nashville Tennessee in January 1998 Each volume contains several invited survey papers written by experts in the field along with contributed research papers This book should be of great interest to mathematicians engineers and computer scientists working in approximation theory wavelets computer aided geometric design CAGD and numerical analysis Among the topics

included in the books are the following adaptive approximation approximation by harmonic functions approximation by radial basis functions approximation by ridge functions approximation in the complex plane Bernstein polynomials bivariate splines constructions of multiresolution analyses convex approximation frames and frame bases Fourier methods generalized moduli of smoothness interpolation and approximation by splines on triangulations multiwavelet bases neural networks nonlinear approximation quadrature and cubature rational approximation refinable functions subdivision schemes thin plate splines wavelets and wavelet systems

Crystal Engineering: The Design and Application of Functional Solids Kenneth Richard Seddon, Kenneth R. Seddon, Michael Zaworotko, 1999-09-30 Crystal engineers need an understanding of bonding theory computational chemistry applied spectroscopy structural methods synthesis strategies and applications of custom designed solids This book contains chapters on all these topics written by internationally recognized experts plus contributions from leading researchers in the field

Navier-Stokes Turbulence Wolfgang Kollmann, 2019-11-21 The book serves as a core text for graduate courses in advanced fluid mechanics and applied science It consists of two parts The first provides an introduction and general theory of fully developed turbulence where treatment of turbulence is based on the linear functional equation derived by E Hopf governing the characteristic functional that determines the statistical properties of a turbulent flow In this section Professor Kollmann explains how the theory is built on divergence free Schauder bases for the phase space of the turbulent flow and the space of argument vector fields for the characteristic functional Subsequent chapters are devoted to mapping methods homogeneous turbulence based upon the hypotheses of Kolmogorov and Onsager intermittency structural features of turbulent shear flows and their recognition

International Workshop on Mathematical Methods and Tools in Computer Simulation, 1994

Mathematical Reviews, 2006

Physics Essays, 1993

Applied Mechanics Reviews, 1969

Reviews in Functional Analysis, 1980-86, 1989

A Course in Mathematical Analysis Edouard Goursat, 1904

American Book Publishing Record Cumulative 1993 R R Bowker Publishing, 1994-03 Cited in BCL3 Sheehy and Walford Compiled from the 12 monthly issues of the ABPR this edition of the annual cumulation lists by Dewey sequence some 41 700 titles for books published or distributed in the US Entry information is derived from MARC II tapes and books submitted to R R Bowker an

Current Index to Statistics, Applications, Methods and Theory, 1997 The Current Index to Statistics CIS is a bibliographic index of publications in statistics probability and related fields

Soviet Mathematics (Iz. VUZ). Soviet Union. Ministerstvo vysshego i srednego spetsial'nogo obrazovaniia, 1978

Application of some methods of mathematical and functional analysis Aleksandr Vasil'evich Efimov, 1985

Journal of the Physical Society of Japan Nihon Butsuri Gakkai, 1992

Reviews in Operator Theory, 1980-86, 1989

The British National Bibliography Arthur James Wells, 1993

Unveiling the Power of Verbal Beauty: An Emotional Sojourn through **Functional Integrals Approximate Evaluations And Applications**

In a world inundated with monitors and the cacophony of quick interaction, the profound power and emotional resonance of verbal artistry often disappear into obscurity, eclipsed by the constant onslaught of noise and distractions. Yet, nestled within the musical pages of **Functional Integrals Approximate Evaluations And Applications**, a interesting perform of fictional beauty that impulses with organic emotions, lies an memorable trip waiting to be embarked upon. Published with a virtuoso wordsmith, that enchanting opus courses readers on a psychological odyssey, gently exposing the latent possible and profound impact stuck within the delicate internet of language. Within the heart-wrenching expanse with this evocative analysis, we will embark upon an introspective exploration of the book is central subjects, dissect its fascinating writing model, and immerse ourselves in the indelible effect it leaves upon the depths of readers souls.

https://upload.sharkcoupons.com/book/scholarship/fetch.php/practice_8_1_ratios_and_proportions_answers.pdf

Table of Contents Functional Integrals Approximate Evaluations And Applications

1. Understanding the eBook Functional Integrals Approximate Evaluations And Applications
 - The Rise of Digital Reading Functional Integrals Approximate Evaluations And Applications
 - Advantages of eBooks Over Traditional Books
2. Identifying Functional Integrals Approximate Evaluations And Applications
 - 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 Functional Integrals Approximate Evaluations And Applications
 - User-Friendly Interface
4. Exploring eBook Recommendations from Functional Integrals Approximate Evaluations And Applications

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

- Fact-Checking eBook Content of Functional Integrals Approximate Evaluations And Applications
 - 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

Functional Integrals Approximate Evaluations And Applications Introduction

Functional Integrals Approximate Evaluations And Applications Offers over 60,000 free eBooks, including many classics that are in the public domain. Open Library: Provides access to over 1 million free eBooks, including classic literature and contemporary works. Functional Integrals Approximate Evaluations And Applications Offers a vast collection of books, some of which are available for free as PDF downloads, particularly older books in the public domain. Functional Integrals Approximate Evaluations And Applications : This website hosts a vast collection of scientific articles, books, and textbooks. While it operates in a legal gray area due to copyright issues, its a popular resource for finding various publications. Internet Archive for Functional Integrals Approximate Evaluations And Applications : Has an extensive collection of digital content, including books, articles, videos, and more. It has a massive library of free downloadable books. Free-eBooks Functional Integrals Approximate Evaluations And Applications Offers a diverse range of free eBooks across various genres. Functional Integrals Approximate Evaluations And Applications Focuses mainly on educational books, textbooks, and business books. It offers free PDF downloads for educational purposes. Functional Integrals Approximate Evaluations And Applications Provides a large selection of free eBooks in different genres, which are available for download in various formats, including PDF. Finding specific Functional Integrals Approximate Evaluations And Applications, especially related to Functional Integrals Approximate Evaluations And Applications, might be challenging as theyre often artistic creations rather than practical blueprints. However, you can explore the following steps to search for or create your own Online Searches: Look for websites, forums, or blogs dedicated to Functional Integrals Approximate Evaluations And Applications, Sometimes enthusiasts share their designs or concepts in PDF format. Books and Magazines Some Functional Integrals Approximate Evaluations And Applications books or magazines might include. Look for these in online stores or libraries. Remember that while Functional Integrals Approximate Evaluations And Applications, sharing copyrighted material without permission is not legal. Always ensure youre either creating your own or obtaining them from legitimate sources that allow sharing and

downloading. Library Check if your local library offers eBook lending services. Many libraries have digital catalogs where you can borrow Functional Integrals Approximate Evaluations And Applications eBooks for free, including popular titles. Online Retailers: Websites like Amazon, Google Books, or Apple Books often sell eBooks. Sometimes, authors or publishers offer promotions or free periods for certain books. Authors Website Occasionally, authors provide excerpts or short stories for free on their websites. While this might not be the Functional Integrals Approximate Evaluations And Applications full book, it can give you a taste of the authors writing style. Subscription Services Platforms like Kindle Unlimited or Scribd offer subscription-based access to a wide range of Functional Integrals Approximate Evaluations And Applications eBooks, including some popular titles.

FAQs About Functional Integrals Approximate Evaluations And Applications Books

1. Where can I buy Functional Integrals Approximate Evaluations And Applications 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 Functional Integrals Approximate Evaluations And Applications 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 Functional Integrals Approximate Evaluations And Applications 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 Functional Integrals Approximate Evaluations And Applications 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 Functional Integrals Approximate Evaluations And Applications books for free? Public Domain Books: Many classic books are available for free as they're in the public domain. Free E-books: Some websites offer free e-books legally, like Project Gutenberg or Open Library.

Find Functional Integrals Approximate Evaluations And Applications :

practice 8 1 ratios and proportions answers

1996 seadoo xp service manua

in search of ancient north america

elasticity in engineering mechanics boresi solution manual

manual for bellsouth answering machine

la chat patapouf un conte danois

stand out second edition national geographic learning

magic tree house dinosaurs before dark

fetal alcohol

in search of ancient mysteries.

honey and ashes

2nd semester geometry chapter 6 review packet answers

essex county resourcee

question paper 1 grade 11 november 2013 geography

topcon instruction manual gpt 6003

Functional Integrals Approximate Evaluations And Applications :

It's Just My Nature! by Carol Tuttle It focuses more on understanding who you actually are (when you were born, in your real nature) vs. looking at who you have become based on the behaviours that ... It's Just My Nature - Carol Tuttle This book very clearly shows how all personalities are rooted in four areas, compared to fire, water, earth, and air... All people have all personalities but it ... It's Just My Nature! A Guide To Knowing and Living ... Carol Tuttle is a teacher, speaker, gifted healer, and best-selling author of 7 books. As a pioneer in the field of personal development, she has dedicated her ... It's Just My Nature! Best-selling author Carol Tuttle provides compelling and life changing ... While Carol offers a variety of assessment tools-including her Dressing Your Truth ... It's Just My Nature!: A Guide to Knowing and Living Your ... Best-selling author Carol Tuttle provides compelling and life changing answers to these simple questions in her newest book It's Just My Nature! It's Just My ... It's Just My Nature! A Guide to Knowing... book by Carol Tuttle I have come to understand through Carol Tuttle's book "It's Just My Nature" that we all have strengths (and weaknesses too, of course). As a Type 2, my nature ... It's Just My Nature! - Dressing Your Truth Store - Carol Tuttle The full overview of Energy Profiling. Teaches a comprehensive study of the 4 Energy Types and how they express in the nature kingdom and human nature. It's Just My Nature (Paperback) Oct 8, 2012 — It's Just My Nature Reveals a startlingly accurate method for assessing your personality and behavioral tendencies with a new system called ... It's Just My Nature (Paperback) Oct 8, 2012 — It's Just My Nature Reveals a startlingly accurate method for assessing your personality and behavioral tendencies with a new system called ... It's Just My Nature (Paperback) Oct 8, 2012 — While Carol offers a variety of assessment tools including her Dressing Your Truth events she leaves the realization of your true Type to you. Neurosis and Human Growth: The Struggle Towards Self- ... In Neurosis and Human Growth, Dr. Horney discusses the neurotic process as a special form of the human development, the antithesis of healthy growth. She ... Neurosis and Human Growth This development and its consequences for the adult personality are what Horney calls neurosis. Horney devotes thirteen chapters to an analysis of the neurotic ... Neurosis and Human Growth | Karen Horney ... Human Growth, The Struggle Towards Self-Realization, Karen Horney, 9780393307757. ... In Neurosis and Human Growth, Dr. Horney discusses the neurotic process as a ... NEUROISIS HUMAN GROWTH KAREN HORNEY, M.D.. NEUROISIS. AND. HUMAN GROWTH. The Struggle Toward. Self-Realization. Neurosis and human growth; the struggle toward self- ... by K Horney · 1950 · Cited by 5872 — Horney, K. (1950). Neurosis and human growth; the struggle toward self-realization. W. W. Norton. Abstract. Presentation of Horney's theory of neurosis ... Neurosis And Human Growth: The Struggle Toward Self- ... Buy Neurosis And Human Growth: The Struggle Toward Self-Realization on Amazon.com ☐ FREE SHIPPING on qualified orders. Neurosis And Human Growth: THE STRUGGLE TOWARD ... In Neurosis and Human Growth, Dr. Horney discusses the neurotic process as a special form of the human development, the antithesis of healthy growth. Episode 148: Karen Horney: Neurosis And Human Growth May 20, 2022 — In a cyclical fashion, neurosis could be influenced

Functional Integrals Approximate Evaluations And Applications

by neuroses in the caretakers of a child. If a caretaker is consumed by their own inner ... Neurosis and Human Growth
Neurosis and human growth: The struggle toward self-realization. New York: W. W. Norton. Bibliography. Horney, Karen.
(1937). The neurotic personality of our ... SAMPLE ELIGIBILITY WORKER I - ... 1. take time to do a careful job, paying more
attention to detail. 2. ask a co-worker who is good at details to proofread ... FAQs Simply list the position title on the
application (example ... Can I submit a resume in lieu of completing the official Yuba County Employment Application form? A
Job with Yuba County Simply list the position title on the application (example ... Can I submit a resume in lieu of completing
the official Yuba County Employment Application form? Eligibility Technician resume example Looking for Eligibility
Technician resume examples online? Check Out one of our best Eligibility Technician resume samples with education, skills
and work ... eligibility-worker-ii | Job Details tab | Career Pages ... Sutter, Tehama, Trinity, Tulare, Ventura, Yolo and Yuba.
#INDSSA. Typical Tasks. Analyzes, evaluates and verifies financial, personal and ... Social Worker II (20438462) - Yuba
County HARD COPY APPLICATION: You may access a hard copy of the Yuba County employment application by visiting our
website at <http://www.yuba.org>. Our applications are ... Medi Cal Eligibility Worker Jobs, Employment 393 Medi Cal
Eligibility Worker jobs available on Indeed.com. Apply to Eligibility Worker, Social Worker, Customer Service Representative
and more! SAR 7 ELIGIBILITY STATUS REPORT Examples include babysitting, salary, self-employment, sick pay, tips. etc. If
you lost your job, attach proof. Job #1. Job #2. Job #3. Name of person who got ... Eligibility Worker I The Eligibility Worker I
is the entry-level classification in the Eligibility Worker series. ... Incumbents will be placed in a work team and initially
may ...