Differential Equations A Primer For Scientists And Engineers Springer Undergraduate Texts In Mathematics And Technology

This book is about dynamical aspects of ordinary differential equations and the relations between dynamical systems and certain fields outside pure mathematics. A prominent role is played by the structure theory of linear operators on finite-dimensional vector spaces; the authors have included a self-contained treatment of that subject.

The calculus of variations is used to find functions that optimize quantities expressed in terms of integrals. Optimal control theory seeks to find functions that minimize cost integrals for systems described by differential equations. This book is an introduction to both the classical theory of the calculus of variations and the more modern developments of optimal control theory from the perspective of an applied mathematician. It focuses on understanding concepts and how to apply them. The range of potential applications is broad: the calculus of variations and optimal control theory have been widely used in numerous ways in biology, criminology, economics, engineering, finance, management science, and physics. Applications described in this book include cancer chemotherapy, navigational control, and renewable resource harvesting. The prerequisites for the book are modest: the standard calculus sequence, a first course on ordinary differential equations, and some facility with the use of mathematical software. It is suitable for an undergraduate or beginning graduate course, or for self study. It provides excellent preparation for more advanced books and courses on the calculus of variations and optimal control theory.

This book is designed as an advanced undergraduate or a first-year graduate course for students from various disciplines like applied mathematics, physics, engineering. It has evolved while teaching courses on partial differential equations during the last decade at the Politecnico of Milan. The main purpose of these courses was twofold: on the one hand, to train the students to appreciate the interplay between theory and modelling in problems arising in the applied sciences and on the other hand to give them a solid background for numerical methods, such as finite differences and finite elements.

This book explains how to solve partial differential equations numerically using single and multidomain spectral methods. It shows how only a few fundamental algorithms form the building blocks of any spectral code, even for problems with complex geometries.

The book serves both as a reference for various scaled models with corresponding dimensionless numbers, and as a resource for learning the art of scaling. A special feature of the book is the emphasis on how to create software for scaled models, based on existing software for unscaled models. Scaling (or non-dimensionalization) is a mathematical technique that greatly simplifies the setting of input parameters in numerical simulations. Moreover, scaling enhances the understanding of how different physical processes interact in a differential equation model. Compared to the existing literature, where the topic of scaling is frequently encountered, but very often in only a brief and shallow setting, the present book gives much more thorough explanations of how to reason about finding the right scales. This process is highly problem dependent, and therefore the book features a lot of worked examples, from very simple ODEs to systems of PDEs, especially from fluid mechanics. The text is easily accessible and example-driven. The first part on ODEs fits even a lower undergraduate level, while the most advanced multiphysics fluid mechanics examples target the graduate level. The scientific literature is full of scaled models, but in most of the cases, the scales are just stated without thorough mathematical reasoning. This book explains how the scales are found mathematically. This book will be a valuable read for anyone doing numerical simulations based on ordinary or partial differential equations.

This book is mainly intended as a textbook for students at the Sophomore-Junior level, majoring in mathematics, engineering, or the sciences in general. The book includes the basic topics in Ordinary Differential Equations, normally taught in an undergraduate class, as linear and nonlinear equations and systems, Bessel functions, Laplace transform, stability, etc. It is written with ample exibility to make it appropriate either as a course stressing applications, or a course stressing rigor and analytical thinking. This book also offers sufficient material for a one-semester graduate course, covering topics such as phase plane analysis, oscillation, Sturm-Liouville equations, Euler-Lagrange equations in Calculus of Variations, first and second order linear PDE in 2D. There are substantial lists of exercises at the ends of chapters. A solutions manual, containing complete and detailed solutions to all the exercises in the book, is available to instructors who adopt the book for teaching their classes.

"...an excellent text for either a short course or self-study... Professor Napolitano has figured out what students really need, and found a way to deliver it... I have found everything he writes to be worthy of my serious attention..." —Peter D. Persans, Professor of Physics and Director, Center for Integrated Electronics, Rensselaer Polytechnic Institute Learn how to use Mathematica quickly for basic problems in physics. The author introduces all the key techniques and then shows how they’re applied using common examples. Chapters cover elementary mathematics concepts, differential and integral calculus, differential equations, vectors and matrices, data analysis, random number generation, animation, and visualization. Written in an appealing, conversational style Presents important concepts within the framework of Mathematics Gives examples from frequently encountered physics problems Explains problem-solving in a step-by-step fashion Jim Napolitano is professor and chair in the Department of Physics at Temple University. He is the author of other textbooks, including co-author with Alistair Rae of Quantum Mechanics, Sixth Edition, also published by Taylor & Francis / CRC Press.

How do biological objects communicate, make structures, make measurements and decisions, search for food, i.e., do all the things necessary for survival? Designed for an advanced undergraduate audience, this book uses mathematics to begin to tell that story. It builds on a background in multivariable calculus, ordinary differential equations, and basic stochastic processes and uses partial differential equations as the framework within which to explore these questions.

This book introduces D-modules and their applications avoiding all unnecessary over-sophistication.

A textbook on mathematical modelling techniques with powerful applications to biology, combining theoretical exposition with exercises and examples.

This text discusses Lie groups of transformations and basic symmetry methods for solving ordinary and partial differential equations. It places emphasis on explicit computational algorithms to discover symmetries admitted by differential equations and to construct solutions resulting from symmetries. This new edition covers contact transformations, Lie-B cklund transformations, and adjoints and integrating factors for ODEs of arbitrary order.

This book offers a comprehensive introduction to modern techniques in the study of free boundary problems of diffusive type. Applications of such methods are thoroughly explained by emblematic examples of the theory and several geometric ideas and insights are carefully discussed, making the text both accessible and appealing to a broad readership working in partial differential equations, calculus of variations, and geometric analysis.

Mathematics and engineering are inevitably interrelated, and this interaction will steadily increase as the use of mathematical modelling grows. Although mathematicians and engineers often misunderstand one another, their basic approach is quite similar, as is the historical development of their respective disciplines. The purpose of this Math Primer is to provide a brief introduction to those parts of mathematics which are, or could be, useful in engineering, especially bioengineering. The aim is to summarize the ideas covered in each subject area without going into exhaustive detail. Formulas and equations have not been avoided, but every effort has been made to keep them simple in the hope of persuading readers that they are not only useful but also accessible. The wide range of topics covered includes introductory material such as numbers and sequences, geometry in two and three dimensions, linear algebra, and the calculus. Building on these foundations, linear spaces, tensor analysis and Fourier analysis are introduced. All these concepts are used to solve problems for ordinary and partial differential equations. Illustrative applications are taken from a variety of engineering disciplines, and the choice of a suitable model is considered from the point of view of both the mathematician and the engineer. This book will be of interest to engineers and bioengineers looking for the mathematical means to help further their work, and it will offer readers a glimpse of many ideas which may spark their interest.

This text on partial differential equations is intended for readers who want to understand the theoretical underpinnings of modern PDEs in settings that are important for the applications without using extensive analytic tools required by most advanced texts. The assumed mathematical background is at the level of multivariable calculus and basic metric space material, but the latter is recalled as relevant as the text progresses. The key goal of this book is to be mathematically complete without overwhelming the reader, and to develop PDE theory in a manner that reflects how researchers would think about the material. A concrete example is that distribution theory and the concept of weak solutions are introduced early because while these ideas take some time for the students to get used to, they are fundamentally easy and, on the other hand, play a central role in the field. Then, Hilbert spaces that are quite important in the later development are introduced via completions which give essentially all the features one wants without the overhead of measure theory. There is additional material provided for readers who would like to learn more than the core material, and there are numerous exercises to help solidify one's understanding. The text should be suitable for advanced undergraduates or for beginning graduate students including those in engineering or the sciences.

This title contains lectures that offer an introduction to modern topics in stochastic partial differential equations and bring together experts whose research is centered on the interface between Gaussian analysis, stochastic analysis, and stochastic PDEs.

Linear Ordinary Differential Equations, a text for advanced undergraduate or beginning graduate students, presents a thorough development of the main topics in linear differential equations. A rich collection of applications, examples, and exercises illustrates each topic. The authors reinforce students' understanding of calculus, linear algebra, and analysis while introducing the many applications of differential equations in science and engineering. Three recurrent themes run through the book. The methods of linear algebra are applied directly to the analysis of systems with constant or periodic coefficients and serve as a guide in the study of eigenvalues and eigenfunction expansions. The use of power series, beginning with the matrix exponential function leads to the special functions solving classical equations. Techniques from real analysis illuminate the development of series solutions, existence theorems for initial value problems, the asymptotic behavior solutions, and the convergence of eigenfunction expansions.

Skillfully organized introductory text examines origin of differential equations, then defines basic terms and outlines the general solution of a differential equation. Subsequent sections deal with integrating factors; dilution and accretion problems; linearization of first order systems; Laplace Transforms; Newton's Interpolation Formulas, more.

Maple is a comprehensive symbolic mathematics application which is well suited for demonstrating physical science topics and solving associated problems. Because Maple is such a rich application, it has a somewhat steep learning curve. Most existing texts concentrate on mathematics; the Maple help facility is too detailed and lacks physical science examples, many Maple-related websites are out of date giving readers information on older Maple versions. This book records the author's journey of discovery; he was familiar with SMath but not with Maple and set out to learn the more advanced application. It leads readers through the basic Maple features with physical science worked examples, giving them a firm base on which to build if more complex features interest them.

This refreshing, introductory textbook covers both standard techniques for solving ordinary differential equations, as well as introducing students to qualitative methods such as phase-plane analysis. The presentation is concise, informal yet rigorous; it can be used either for 1-term or 1-semester courses. Topics such as Euler's method, difference equations, the dynamics of the logistic map, and the Lorenz equations, demonstrate the vitality of the subject, and provide pointers to further study. The author also encourages a graphical approach to the equations and their solutions, and to that end the book is profusely illustrated. The files to produce the figures using MATLAB are all provided in an accompanying website. Numerous worked examples provide motivation for and illustration of key ideas and show how to make the transition from theory to practice. Exercises are also provided to test and extend understanding: solutions for these are available for teachers.

This textbook is for the standard, one-semester, junior-senior course that often goes by the title "Elementary Partial Differential Equations" or "Boundary Value Problems;' The audience usually consists of stu dents in mathematics, engineering, and the physical sciences. The topics include derivations of some of the standard equations of mathemati cal physics (including the heat equation, the· wave equation, and the Laplace's equation) and methods for solving those equations on bounded and unbounded domains. Methods include eigenfunction expansions or separation of variables, and methods based on Fourier and Laplace transforms. Prerequisites include calculus and a post-calculus differential equations course. There are several excellent texts for this course, so one can legitimately ask why one would wish to write another. A survey of the content of the existing titles shows that their scope is broad and the analysis detailed; and they often exceed five hundred pages in length. These books gen erally have enough material for two, three, or even four semesters. Yet, many undergraduate courses are one-semester courses. The author has often felt that students become a little uncomfortable when an instructor jumps around in a long volume searching for the right topics, or only par tially covers some topics; but they are secure in completely mastering a short, well-defined introduction. This text was written to proVide a brief, one-semester introduction to partial differential equations.

The Wavelet Transform has stimulated research that is unparalleled since the invention of the Fast Fourier Transform and has opened new avenues of applications in signal processing, image compression, radiology, cardiology, and many other areas. This book grew out of a short course for mathematics students at the ETH in Zurich; it provides a solid mathematical foundation for the broad range of applications enjoyed by the wavelet transform. Numerous illustrations and fully worked out examples enhance the book.

The general area of stochastic PDEs is interesting to mathematicians because it contains an enormous number of challenging open problems. There is also a great deal of interest in this topic because it has deep applications in disciplines that range from applied mathematics, statistical mechanics, and theoretical physics, to theoretical neuroscience, theory of complex chemical reactions [including polymer science], fluid dynamics, and mathematical finance. The stochastic PDEs that are studied in this book are similar to the familiar PDE for heat in a thin rod, but with the additional restriction that the external forcing density is a two-parameter stochastic process, or what is more commonly the case, the forcing is a "random noise," also known as a "generalized random field." At several points in the lectures, there are examples that highlight the phenomenon that stochastic PDEs are not a subset of PDEs. In fact, the introduction of noise in some partial differential equations can bring about not a small perturbation, but truly fundamental changes to the system that the underlying PDE is attempting to describe. The topics covered include a brief introduction to the stochastic heat equation, structure theory for the linear stochastic heat equation, and an in-depth look at intermittency properties of the solution to semilinear stochastic heat equations. Specific topics include stochastic integrals à la Norbert Wiener, an infinite-dimensional Itô-type stochastic integral, an example of a parabolic Anderson model, and intermittency fronts. There are many possible approaches to stochastic PDEs. The selection of topics and techniques presented here are informed by the guiding example of the stochastic heat equation. A co-publication of the AMS and CBMS.

Therearemanyexcellenttextsonelementarydi?erentialequationsdesignedfor the standard sophomore course. However, in spite of the fact that most courses are one semester in length, the texts have evolved into calculus-like pres- tations that include a large collection of methods and applications, packaged with student manuals, and Web-based notes, projects, and supplements. All of this comes in several hundred pages of text with busy formats. Most students do not have the time or desire to read voluminous texts and explore internet supplements. The format of this di?erential equations book is di?erent; it is a one-semester, brief treatment of the basic ideas, models, and solution methods. Itslimitedcoverageplacesitsomewherebetweenanoutlineandadetailedte- book. I have tried to write concisely, to the point, and in plain language. Many worked examples and exercises are included. A student who works through this primer will have the tools to go to the next level in applying di?erential eq- tions to problems in engineering, science, and applied mathematics. It can give some instructors, who want more concise coverage, an alternative to existing texts.

This book provides a self-contained introduction to ordinary differential equations and dynamical systems suitable for beginning graduate students. The first part begins with some simple examples of explicitly solvable equations and a first glance at qualitative methods. Then the fundamental results concerning the initial value problem are proved: existence, uniqueness, extensibility, dependence on initial conditions. Furthermore, linear equations are considered, including the Floquet theorem, and some perturbation results. As somewhat independent topics, the Frobenius method for linear equations in the complex domain is established and Sturm-Liouville boundary value problems, including oscillation theory, are investigated. The second part introduces the concept of a dynamical system. The Poincare-Bendixson theorem is proved, and several examples of planar systems from classical mechanics, ecology, and electrical engineering are investigated. Moreover, attractors, Hamiltonian systems, the KAM theorem, and periodic solutions are discussed. Finally, stability is studied, including the stable manifold and the Hartman-Grobman theorem for both continuous and discrete systems. The third part introduces chaos, beginning with the basics for iterated interval maps and ending with the Smale-Birkhoff theorem and the Melnikov method for homoclinic orbits. The text contains almost three hundred exercises. Additionally, the use of mathematical software systems is incorporated throughout, showing how they can help in the study of differential equations.

The subject of real analytic functions is one of the oldest in mathe matical analysis. Today it is encountered early in ones mathematical training: the first taste usually comes in calculus. While most work ing mathematicians use real analytic functions from time to time in their work, the vast lore of real analytic functions remains obscure and buried in the literature. It is remarkable that the most accessible treatment of Puiseux's theorem is in Lefschetz's quite old Algebraic Geometry, that the clearest discussion of resolution of singularities for real analytic manifolds is in a book review by Michael Atiyah, that there is no comprehensive discussion in print of the embedding prob lem for real analytic manifolds. We have had occasion in our collaborative research to become ac quainted with both the history and the scope of the theory of real analytic functions. It seems both appropriate and timely for us to gather together this information in a single volume. The material presented here is of three kinds. The elementary topics, covered in Chapter 1, are presented in great detail. Even results like a real ana lytic inverse function theorem are difficult to find in the literature, and we take pains here to present such topics carefully. Topics of middling difficulty, such as separate real analyticity, Puiseux series, the FBI transform, and related ideas (Chapters 2-4), are covered thoroughly but rather more briskly.

This book offers readers a primer on the theory and applications of Ordinary Differential Equations. The style used is simple, yet thorough and rigorous. Each chapter ends with a broad set of exercises that range from the routine to the more challenging and thought-provoking. Solutions to selected exercises can be found at the end of the book. The book contains many interesting examples on topics such as electric circuits, the pendulum equation, the logistic equation, the Lotka-Volterra system, the Laplace Transform, etc., which introduce students to a number of interesting aspects of the theory and applications. The work is mainly intended for students of Mathematics, Physics, Engineering, Computer Science and other areas of the natural and social sciences that use ordinary differential equations, and who have a firm grasp of Calculus and a minimal understanding of the basic concepts used in Linear Algebra. It also studies a few more advanced topics, such as Stability Theory and Boundary Value Problems, which may be suitable for more advanced undergraduate or first-year graduate students. The second edition has been revised to correct minor errata, and features a number of carefully selected new exercises, together with more detailed explanations of some of the topics. A complete Solutions Manual, containing solutions to all the exercises published in the book, is available. Instructors who wish to adopt the book may request the manual by writing directly to one of the authors.

Covers ODEs and PDEs—in One Textbook Until now, a comprehensive textbook covering both ordinary differential equations (ODEs) and partial differential equations (PDEs) didn't exist. Fulfilling this need, Ordinary and Partial Differential Equations provides a complete and accessible course on ODEs and PDEs using many examples and exercises as well as intuitive, easy-to-use software. Teaches the Key Topics in Differential Equations The text includes all the topics that form the core of a modern undergraduate or beginning graduate course in differential equations. It also discusses other optional but important topics such as integral equations, Fourier series, and special functions. Numerous carefully chosen examples offer practical guidance on the concepts and techniques. Guides Students through the Problem-Solving Process Requiring no user programming, the accompanying computer software allows students to fully investigate problems, thus enabling a deeper study into the role of boundary and initial conditions, the dependence of the solution on the parameters, the accuracy of the solution, the speed of a series convergence, and related questions. The ODE module compares students' analytical solutions to the results of computations while the PDE module demonstrates the sequence of all necessary analytical solution steps.

The mathematical formulations of problems in physics, economics, biology, and other sciences are usually embodied in differential equations. The analysis of the resulting equations then provides new insight into the original problems. This book describes the tools for performing that analysis. The first chapter treats single differential equations, emphasizing linear and nonlinear first order equations, linear second order equations, and a class of nonlinear second order equations arising from Newton's laws. The first order linear theory starts with a self-contained presentation of the exponential and trigonometric functions, which plays a central role in the subsequent development of this chapter. Chapter 2 provides a mini-course on linear algebra, giving detailed treatments of linear transformations, determinants and invertibility, eigenvalues and eigenvectors, and generalized eigenvectors. This treatment is more detailed than that in most differential equations texts, and provides a solid foundation for the next two chapters. Chapter 3 studies linear systems of differential equations. It starts with the matrix exponential, melding material from Chapters 1 and 2, and uses this exponential as a key tool in the linear theory. Chapter 4 deals with nonlinear systems of differential equations. This uses all the material developed in the first three chapters and moves it to a deeper level. The chapter includes theoretical studies, such as the fundamental existence and uniqueness theorem, but also has numerous examples, arising from Newtonian physics, mathematical biology, electrical circuits, and geometrical problems. These studies bring in variational methods, a fertile source of nonlinear systems of differential equations. The reader who works through this book will be well prepared for advanced studies in dynamical systems, mathematical physics, and partial differential equations.

The fundamental mathematical tools needed to understand machine learning include linear algebra, analytic geometry, matrix decompositions, vector calculus, optimization, probability and statistics. These topics are traditionally taught in disparate courses, making it hard for data science or computer science students, or professionals, to efficiently learn the mathematics. This self-contained textbook bridges the gap between mathematical and machine learning texts, introducing the mathematical concepts with a minimum of prerequisites. It uses these concepts to derive four central machine learning methods: linear regression, principal component analysis, Gaussian mixture models and support vector machines. For students and others with a mathematical background, these derivations provide a starting point to machine learning texts. For those learning the mathematics for the first time, the methods help build intuition and practical experience with applying mathematical concepts. Every chapter includes worked examples and exercises to test understanding. Programming tutorials are offered on the book's web site.

This is a textbook for an introductory graduate course on partial differential equations. Han focuses on linear equations of first and second order. An important feature of his treatment is that the majority of the techniques are applicable more generally. In particular, Han emphasizes a priori estimates throughout the text, even for those equations that can be solved explicitly. Such estimates are indispensable tools for proving the existence and uniqueness of solutions to PDEs, being especially important for nonlinear equations. The estimates are also crucial to establishing properties of the solutions, such as the continuous dependence on parameters. Han's book is suitable for students interested in the mathematical theory of partial differential equations, either as an overview of the subject or as an introduction leading to further study.

In this book we describe the magic world of mathematical models: starting from real-life problems, we formulate them in terms of equations, transform equations into algorithms and algorithms into programs to be executed on computers. A broad variety of examples and exercises illustrate that properly designed models can, e.g.: predict the way the number of dolphins in the Aeolian Sea will change as food availability and fishing activity vary; describe the blood flow in a capillary network; calculate the PageRank of websites. This book also includes a chapter with an elementary introduction to Octave, an open-source programming language widely used in the scientific community. Octave functions and scripts for dealing with the problems presented in the text can be downloaded from https://paola-gervasio.unibs.it/quarteroni-gervasio This book is addressed to any student interested in learning how to construct and apply mathematical models.

This highly readable book aims to ease the many challenges of starting undergraduate research. It accomplishes this by presenting a diverse series of self-contained, accessible articles which include specific open problems and prepare the reader to tackle them with ample background material and references. Each article also contains a carefully selected bibliography for further reading. The content spans the breadth of mathematics, including many topics that are not normally addressed by the undergraduate curriculum (such as matroid theory, mathematical biology, and operations research), yet have few enough prerequisites that the interested student can start exploring them under the guidance of a faculty member. Whether trying to start an undergraduate thesis, embarking on a summer REU, or preparing for graduate school, this book is appropriate for a variety of students and the faculty who guide them.

Solution Techniques for Elementary Partial Differential Equations, Third Edition remains a top choice for a standard, undergraduate-level course on partial differential equations (PDEs). Making the text even more user-friendly, this third edition covers important and widely used methods for solving PDEs. New to the Third Edition New sections on the series expansion of more general functions, other problems of general second-order linear equations, vibrating string with other types of boundary conditions, and equilibrium temperature in an infinite strip Reorganized sections that make it easier for students and professors to navigate the contents Rearranged exercises that are now at the end of each section/subsection instead of at the end of the chapter New and improved exercises and worked examples A brief Mathematica® program for nearly all of the worked examples, showing students how to verify results by computer This bestselling, highly praised textbook uses a streamlined, direct approach to develop students' competence in solving PDEs. It offers concise, easily understood explanations and worked examples that allow students to see the techniques in action.

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This textbook is designed with the needs of today's student in mind. It is the ideal textbook for a first course in elementary differential equations for future engineers and scientists, including mathematicians. This book is accessible to anyone who has a basic knowledge of precalculus algebra and differential and integral calculus. Its carefully crafted text adopts a concise, simple, no-frills approach to differential equations, which helps students acquire a solid experience in many classical solution techniques. With a lighter accent on the physical interpretation of the results, a more manageable page count than comparable texts, a highly readable style, and over 1000 exercises designed to be solved without a calculating device, this book emphasizes the understanding and practice of essential topics in a succinct yet fully rigorous fashion. Apart from several other enhancements, the second edition contains one new chapter on numerical methods of solution. The book formally splits the "pure" and "applied" parts of the contents by placing the discussion of selected mathematical models in separate chapters. At the end of most of the 246 worked examples, the author provides the commands in Mathematica® for verifying the results. The book can be used independently by the average student to learn the fundamentals of the subject, while those interested in pursuing more advanced material can regard it as an easily taken first step on the way to the next level. Additionally, practitioners who encounter differential equations in their professional work will find this text to be a convenient source of reference.

Mathematics plays an important role in many scientific and engineering disciplines. This book deals with the numerical solution of differential equations, a very important branch of mathematics. Our aim is to give a practical and theoretical account of how to solve a large variety of differential equations, comprising ordinary differential equations, initial value problems and boundary value problems, differential algebraic equations, partial differential equations and delay differential equations. The solution of differential equations using R is the main focus of this book. It is therefore intended for the practitioner, the student and the scientist, who wants to know how to use R for solving differential equations. However, it has been our goal that non-mathematicians should at least understand the basics of the methods, while obtaining entrance into the relevant literature that provides more mathematical background. Therefore, each chapter that deals with R examples is preceded by a chapter where the theory behind the numerical methods being used is introduced. In the sections that deal with the use of R for solving differential equations, we have taken examples from a variety of disciplines, including biology, chemistry, physics, pharmacokinetics. Many examples are well-known test examples, used frequently in the field of numerical analysis.

?This book presents a concise introduction to a unified Hilbert space approach to the mathematical modelling of physical phenomena which has been developed over recent years by Picard and his co-workers. The main focus is on time-dependent partial differential equations with a particular structure in the Hilbert space setting that ensures well-posedness and causality, two essential properties of any reasonable model in mathematical physics or engineering.However, the application of the theory to other types of equations is also demonstrated. By means of illustrative examples, from the straightforward to the more complex, the authors show that many of the classical models in mathematical physics as well as more recent models of novel materials and interactions are covered, or can be restructured to be covered, by this unified Hilbert space approach. The reader should require only a basic foundation in the theory of Hilbert spaces and operators therein. For convenience, however, some of the more technical background requirements are covered in detail in two appendices The theory is kept as elementary as possible, making the material suitable for a senior undergraduate or master’s level course. In addition, researchers in a variety of fields whose work involves partial differential equations and applied operator theory will also greatly benefit from this approach to structuring their mathematical models in order that the general theory can be applied to ensure the essential properties of well-posedness and causality.