

Exercise 1

Verify the linearity and nonlinearity of the eight examples of PDEs given in the text, by checking whether or not equations (3) are valid.

Solution

The eight examples in the text are given below.

1. $u_x + u_y = 0$ (transport)
2. $u_x + yu_y = 0$ (transport)
3. $u_x + uu_y = 0$ (shock wave)
4. $u_{xx} + u_{yy} = 0$ (Laplace's equation)
5. $u_{tt} - u_{xx} + u^3 = 0$ (wave with interaction)
6. $u_t + uu_x + u_{xxx} = 0$ (dispersive wave)
7. $u_{tt} + u_{xxxx} = 0$ (vibrating bar)
8. $u_t - iu_{xx} = 0$ ($i = \sqrt{-1}$) (quantum mechanics)

The equations in (3) are $\mathcal{L}(u+v) = \mathcal{L}u + \mathcal{L}v$ and $\mathcal{L}(cu) = c\mathcal{L}u$, which state the conditions for linearity. They will be checked in each case.

Example One:

$$\begin{aligned}
 u_x + u_y &= 0 && \text{(transport)} \\
 \frac{\partial}{\partial x}u + \frac{\partial}{\partial y}u &= 0 && \text{(change notation)} \\
 \left(\frac{\partial}{\partial x} + \frac{\partial}{\partial y} \right) u &= 0 && \text{(factor the common term)} \\
 \mathcal{L}u &= 0
 \end{aligned}$$

Therefore, for this example, the operator we are working with is

$$\mathcal{L} = \frac{\partial}{\partial x} + \frac{\partial}{\partial y}$$

Now the equations in (3) may be verified. Suppose u and v are solutions to the PDE. The first equation in (3) yields

$$\begin{aligned}
 \mathcal{L}(u+v) &= \left(\frac{\partial}{\partial x} + \frac{\partial}{\partial y} \right) (u+v) \\
 &= \frac{\partial}{\partial x}(u+v) + \frac{\partial}{\partial y}(u+v) \\
 &= \frac{\partial}{\partial x}u + \frac{\partial}{\partial x}v + \frac{\partial}{\partial y}u + \frac{\partial}{\partial y}v \\
 &= \frac{\partial}{\partial x}u + \frac{\partial}{\partial y}u + \frac{\partial}{\partial x}v + \frac{\partial}{\partial y}v \\
 &= \left(\frac{\partial}{\partial x} + \frac{\partial}{\partial y} \right) u + \left(\frac{\partial}{\partial x} + \frac{\partial}{\partial y} \right) v \\
 &= \mathcal{L}u + \mathcal{L}v
 \end{aligned}$$

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Rosina Ehmann



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Partial Differential Equations: An Introduction, 2e Student Solutions Manual Julie L. Levandosky, Steven P. Levandosky, Walter A. Strauss, 2008-02-25 Practice partial differential equations with this student solutions manual Corresponding chapter by chapter with Walter Strauss's *Partial Differential Equations* this student solutions manual consists of the answer key to each of the practice problems in the instructional text Students will follow along through each of the chapters providing practice for areas of study including waves and diffusions reflections and sources boundary problems Fourier series harmonic functions and more Coupled with Strauss's text this solutions manual provides a complete resource for learning and practicing partial differential equations

Waves And Rays In Elastic Continua (3rd Edition) Michael A Slawinski, 2014-12-15 The present book which is the third significantly revised edition of the textbook originally published by Elsevier Science emphasizes the interdependence of mathematical formulation and physical meaning in the description of seismic phenomena Herein we use aspects of continuum mechanics wave theory and ray theory to explain phenomena resulting from the propagation of seismic waves The book is divided into three main sections Elastic Continua Waves and Rays and Variational Formulation of Rays There is also a fourth part which consists of appendices In Elastic Continua we use continuum mechanics to describe the material through which seismic waves propagate and to formulate a system of equations to study the behaviour of such a material In Waves and Rays we use these equations to identify the types of body waves propagating in elastic continua as well as to express their velocities and displacements in terms of the properties of these continua To solve the equations of motion in anisotropic inhomogeneous continua we invoke the concept of a ray In Variational Formulation of Rays we show that in elastic continua a ray is tantamount to a trajectory along which a seismic signal propagates in accordance with the variational principle of stationary traveltime Consequently many seismic problems in elastic continua can be conveniently formulated and solved using the calculus of variations In the Appendices we describe two mathematical concepts that are used in the book namely homogeneity of a function and Legendre's transformation This section also contains a list of symbols

Partial Differential Equations Walter A. Strauss, 2007-12-21 Our understanding of the fundamental processes of the natural world is based to a large extent on partial differential equations PDEs The second edition of *Partial Differential Equations* provides an introduction to the basic properties of PDEs and the ideas and techniques that have proven useful in analyzing them It provides the student a broad perspective on the subject illustrates the incredibly rich variety of phenomena encompassed by it and imparts a working knowledge of the most important techniques of analysis of the solutions of the equations In this book mathematical jargon is minimized Our focus is on the three most classical PDEs the wave heat and Laplace equations Advanced concepts are introduced frequently but with the least possible technicalities The book is flexibly designed for juniors seniors or beginning graduate students in science engineering or mathematics

Waves And Rays In Elastic Continua (Fourth Edition) Michael A Slawinski, 2020-09-24

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Books In Print 2004-2005 Ed Bowker Staff,Staff Bowker, Ed,2004 **Simulation** ,1970 **International Books in Print** ,1990 Computational Fluid Dynamics and Energy Modelling in Buildings Parham A. Mirzaei,2023-01-24 COMPUTATIONAL FLUID DYNAMICS AND ENERGY MODELLING IN BUILDINGS A Comprehensive Overview of the Fundamentals of Heat and Mass Transport Simulation and Energy Performance in Buildings In the first part of Computational Fluid Dynamics and Energy Modelling in Buildings Fundamentals and Applications the author explains the fundamentals of fluid mechanics thermodynamics and heat transfer with a specific focus on their application in buildings This background knowledge sets the scene to further model heat and mass transport in buildings with explanations of commonly applied simplifications and assumptions In the second part the author elaborates how the fundamentals explained in part 1 can be used to model energy flow in buildings which is the basis of all commercial and educational building energy simulation tools An innovative illustrative nodal network concept is introduced to help readers comprehend the basics of conservation laws in buildings The application of numerical techniques to form dynamic simulation tools are then introduced In general understanding these techniques will help readers to identify and justify their choices when working with building energy simulation tools rather than using default settings Detailed airflow information in buildings cannot be obtained in building energy simulation techniques Therefore part three is focused on introducing computational fluid dynamics CFD as a detailed modelling technique for airflow in buildings This part starts with an introduction to the fundamentals of the finite volume method used to solve the governing fluid equations and the related challenges and considerations are discussed The last chapter of this part covers the solutions to some practical problems of airflow within and around buildings The key aspect of Computational Fluid Dynamics and Energy Modelling in Buildings Fundamentals and Applications is that it is tailored for audiences without extensive past experience of numerical methods Undergraduate or graduate students in architecture urban planning geography architectural engineering and other engineering fields along with building performance and simulation professionals can use this book to gain additional clarity on the topics of building energy simulation and computational fluid dynamics Proceedings ,1977 **Proceedings of the Army Numerical and Computers Analysis Conference** ,1977 **Paperbound Books in Print** ,1992 Forthcoming

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