

# AN INTRODUCTION TO CATASTROPHE THEORY AND ITS APPLICATIONS\*

MARTIN GOLUBITSKY†

**Abstract.** This article is divided into two parts. In the first we give a description of the basic theorems of elementary catastrophe theory, along with heuristic explanations of why these theorems are valid. In particular, the main ideas in Mather's proof of Thom's classification theorem are presented.

The second part contains three applications of catastrophe theory to the buckling of beams, optics, and convex conservation laws. In these sections we attempt to state the problems precisely, to show how catastrophe theory may be used in a mathematically rigorous fashion, and to state what new information can be obtained by the use of catastrophe theory.

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**Introduction.** During the past decade catastrophe theory, created by René Thom in his book *Structural Stability and Morphogenesis* [32], has generated substantial interest among both mathematicians and users of mathematics. Various comments about catastrophe theory have ranged from "the first theory to explain how a continuous change of parameters can cause discontinuous phenomena" or "the type of mathematics necessary to study qualitative problems in biology and the social sciences" to "some nice observations surrounded by totally unwarranted speculation." The truth, as usual, probably lies somewhere in between.

There now exist several expository articles describing catastrophe theory to the lay audience ([37], [24], [29], [27], [54], and [30]) and several expositions concerned with the technical theorems—first proved by John Mather [19]—which require relatively large investments of time and energy for most mathematicians to absorb and appreciate ([5], [36], [35], [50], [60], [55], and [21]).

Our purpose, in the first part of this article, is to give concise but complete descriptions of the basic theorems of elementary catastrophe theory along with heuristic descriptions explaining why these theorems should be true. In the second part we describe some applications which—we hope—will indicate some of the power and limitations of this theory.

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# Catastrophe Theory And Its Applications

**Martin Golubitsky**



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**Catastrophe Theory** Vladimir I. Arnol'd, 2012-12-06 This well known booklet now in its third expanded edition provides an informal survey of applications of singularity theory in a wide range of areas Although the first few chapters touch briefly and critically on the Thom-Zeeman catastrophe theory most of the book is concerned with more recent and less controversial aspects covering such topics as bifurcations and stability loss wavefront propagation the distribution of matter in the universe optimization and control problems visible contours bypassing an obstacle symplectic and contact geometry complex singularities and the surprising connections between singularities and widely disparate mathematical objects such as regular polyhedra and reflection groups Readers familiar with the previous editions will find much that is new Results have been brought up to date and among the new or expanded topics discussed are delayed loss of stability cascades of period doublings and triplings shock waves implicit differential equations and folded singularities interior scattering and more Three new sections give an overview of the history of singularity theory and its applications from Leonardo da Vinci to modern times a discussion of perestroika in terms of the theory of metamorphoses and a list of 93 problems touching on most of the subject matter in the book The text is enhanced by fifteen new drawings there are now 87 in all and improvements to old ones The already extensive literature list has been updated and expanded As a result the book has been enlarged by almost a third Arnol'd's goal with this edition remains the same to explain the essence of the results and applications to readers having a minimal mathematical background All that he asks is that the reader have an inquiring mind Catastrophe Theory for Scientists and Engineers Robert Gilmore, 1993-01-01 This advanced level treatment describes the mathematics of

catastrophe theory and its applications to problems in mathematics physics chemistry and engineering 28 tables 397 black and white illustrations 1981 edition      **Singularity Theory and an Introduction to Catastrophe Theory** Y.-C.

Lu,2012-12-06 In April 1975 I organised a conference at the Battelle Research Center Seattle Washington on the theme Structural stability catastrophe theory and their applications in the sciences To this conference were invited a number of mathematicians concerned with the mathematical theories of structural stability and catastrophe theory and other mathematicians whose principal interest lay in applications to various sciences physical biological medical and social Rene Thorn and Christopher Zeeman figured in the list of distinguished participants The conference aroused considerable interest and many mathematicians who were not specialists in the fields covered by the conference expressed their desire to attend the conference sessions in addition scientists from the Battelle laboratories came to Seattle to learn of developments in these areas and to consider possible applications to their own work In view of the attendance of these mathematicians and scientists and in order to enable the expositions of the experts to be intelligible to this wider audience I invited Professor Yung Chen Lu of Ohio State University to come to Battelle Seattle in advance of the actual conference to deliver a series of informal lecture seminars explaining the background of the mathematical theory and indicating some of the actual and possible applications In the event Yung Chen Lu delivered his lectures in the week preceding and the week following the actual conference so that the first half of his course was preparatory and the second half explanatory and evaluative These lecture notes constitute an expanded version of the course      An Exposition of Catastrophe Theory and Its Applications to Phase Transitions D. O'Shea,1975      An Exposition of Catastrophe Theory and Its Applications to Phase Transitions Donal

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Cooke,2014-05-10 Transformations Mathematical Approaches to Culture Change focuses on the application of contemporary mathematical techniques to the study of culture change and formulates problems in archaeology anthropology and historiography in such a way that they are susceptible to treatment of a mathematical kind Mathematical models extending from the almost purely quantitative methods of physics to the purely verbal conceptual explanations are described Emphasis is placed on catastrophe theoretic models that exemplify the use of soft mathematics in situations in which the use of hard quantitative models is not possible Comprised of 21 chapters this book begins with an overview of the role of mathematics in theoretical archaeology followed by a discussion on two general categories of mathematical methods that seem to be suitable for modeling cultural transformations methods of dynamical systems theory and methods that give greater emphasis on discrete entities and the structural relations or patterns among them Subsequent chapters deal with the use of mathematics

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