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.

CONTENTS

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.

Introduction To Catastrophe Theory

Ronald E. Mickens

Introduction To Catastrophe Theory:

   An Introduction to Catastrophe Theory Peter Timothy Saunders,1980-06-30 An introduction to catastrophe theory a mathematical theory which deals with those changes which occur abruptly rather than smoothly Includes many applications to illustrate the different ways in which catastrophe can be used in life physical and social sciences   <u>Singularity Theory and an Introduction to Catastrophe Theory</u> Y.-C. Lu,1976 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   **Singularity Theory and an Introduction to Catastrophe Theory** Yung-Chen Lu,1976   **Introduction to Catastrophe Theory** Barry Clay Hall,1980   **Catastrophe Theory** A. Okninski,1992-06-12 This book aims to provide a straightforward introduction to chemical applications of the catastrophe theory It is primarily intended for chemists interested in placing chemical reactions in the broader context of non linear science but it has a practical relevance for scientists in general Catastrophe theory deals with those non linear phenomena in which a continuous change in the control parameters results in a discontinuous alteration of a characteristic quantity of the system The author discusses the origins of catastrophe theory giving examples of occurrences in the areas of physics chemistry and biology Elementary theory and non chemical applications are also described The chemical kinetics and methods of analysis of chemical kinetic equations arising from elementary and generalized catastrophe theories are reviewed Finally the theory is applied to analyse and classify phenomena associated with the stability loss that may occur in chemical reactions The book contains over 100 figures and an extensive subject index   *Catastrophe Theory* Vladimir I. Arnol'd,2012-12-06   **An Introduction to Catastrophe Theory and Its Applications** Martin Golubitsky,1978*   **Catastrophe Theory** Vladimir I. Arnol'd,2003-10-29 The new edition of this non mathematical

review of catastrophe theory contains updated results and many new or expanded topics including delayed loss of stability shock waves and interior scattering Three new sections offer the history of singularity and its applications from da Vinci to today a discussion of perestroika in terms of the theory of metamorphosis and a list of 93 problems touching on most of the subject matter in the book   Singurity Theory and an Introduction to Catastrophe Theory Yung-chen Lu,1976   **BIOS Instant Notes in Sport and Exercise Psychology** Dave Shaw,Trish Gorely,Rod Corban,2004-10-15 Instant Notes in Sport and Exercise Psychology provides concise coverage of sport and exercise psychology at the undergraduate level and also covers the crucial basic psychology that underpins the subject It has four main themes theoretical approaches and research methods sport psychology at both the individual and group level of analysis exercise psychology practical applications including performance enhancement and ethics Suitable for students in sport and exercise science sport psychology sport studies and sports management it will be useful for coaches and athletes who wish to gain an up to date understanding of the key concepts theories and research in this area   Catastrophe Theory Domencio Castrigiano,2019-06-03 Catastrophe Theory was introduced in the 1960s by the renowned Fields Medal mathematician Ren Thom as a part of the general theory of local singularities Since then it has found applications across many areas including biology economics and chemical kinetics By investigating the phenomena of bifurcation and chaos Catastrophe Theory proved to   **CRC Concise Encyclopedia of Mathematics** Eric W. Weisstein,2002-12-12 Upon publication the first edition of the CRC Concise Encyclopedia of Mathematics received overwhelming accolades for its unparalleled scope readability and utility It soon took its place among the top selling books in the history of Chapman Hall CRC and its popularity continues unabated Yet also unabated has been the d   *An Introduction to the Theory of Large Deviations* D.W. Stroock,2012-12-06 These notes are based on a course which I gave during the academic year 1983 84 at the University of Colorado My intention was to provide both my audience as well as myself with an introduction to the theory of 1arie deviations The organization of sections 1 through 3 owes something to chance and a great deal to the excellent set of notes written by R Azencott for the course which he gave in 1978 at Saint Flour cf Springer Lecture Notes in Mathematics 774 To be more precise it is chance that I was around N Y U at the time when M Schilder wrote his thesis and so it may be considered chance that I chose to use his result as a jumping off point with only minor variations everything else in these sections is taken from Azencott In particular section 3 is little more than a rewrite of his exoposition of the Cramer theory via the ideas of Bahadur and Zabel Furthermore the brief treatment which I have given to the Ventsel Freidlin theory in section 4 is again based on Azencott s ideas All in all the biggest difference between his and my exposition of these topics is the language in which we have written However another major difference must be mentioned his bibliography is extensive and constitutes a fine introduction to the available literature mine shares neither of these attributes Starting with section 5   **Mathematics of Complexity and Dynamical Systems** Robert A. Meyers,2011-10-05 Mathematics of Complexity and Dynamical Systems is an authoritative reference to

the basic tools and concepts of complexity systems theory and dynamical systems from the perspective of pure and applied mathematics Complex systems are systems that comprise many interacting parts with the ability to generate a new quality of collective behavior through self organization e g the spontaneous formation of temporal spatial or functional structures These systems are often characterized by extreme sensitivity to initial conditions as well as emergent behavior that are not readily predictable or even completely deterministic The more than 100 entries in this wide ranging single source work provide a comprehensive explication of the theory and applications of mathematical complexity covering ergodic theory fractals and multifractals dynamical systems perturbation theory solitons systems and control theory and related topics Mathematics of Complexity and Dynamical Systems is an essential reference for all those interested in mathematical complexity from undergraduate and graduate students up through professional researchers *An Introduction to Catastrophe Theory and a Model of the Origin of Economic Crises* Giacomo Bonanno,1984 **An Introduction to Nonlinear Oscillations** Ronald E. Mickens,1981 An introductory account of the equations describing nonlinear oscillations the methods for solving them An Introduction to Linear Programming and the Theory of Games Abraham M. Glicksman,2001-01-01 Simple exposition of linear programming and matrix games covers convex sets in the Cartesian plane and the fundamental extreme point theorem for convex polygons the simplex method in linear programming the fundamental duality theorem and its corollary von Neumann s minimax theorem more Easily understood problems and illustrative exercises 1963 edition **Introduction to the Theory of Sets** Joseph Breuer,2012-08-09 This undergraduate text develops its subject through observations of the physical world covering finite sets cardinal numbers infinite cardinals and ordinals Includes exercises with answers 1958 edition

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