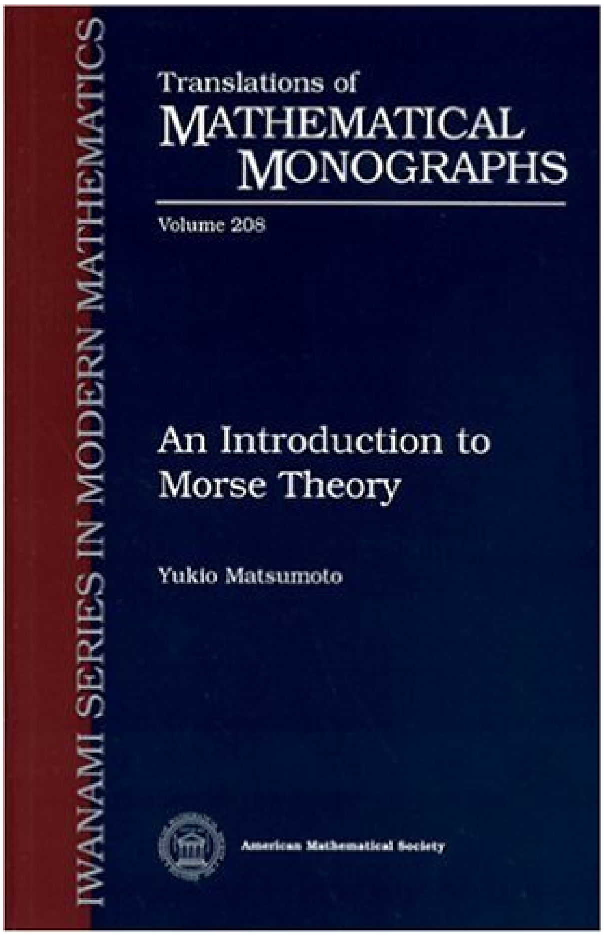
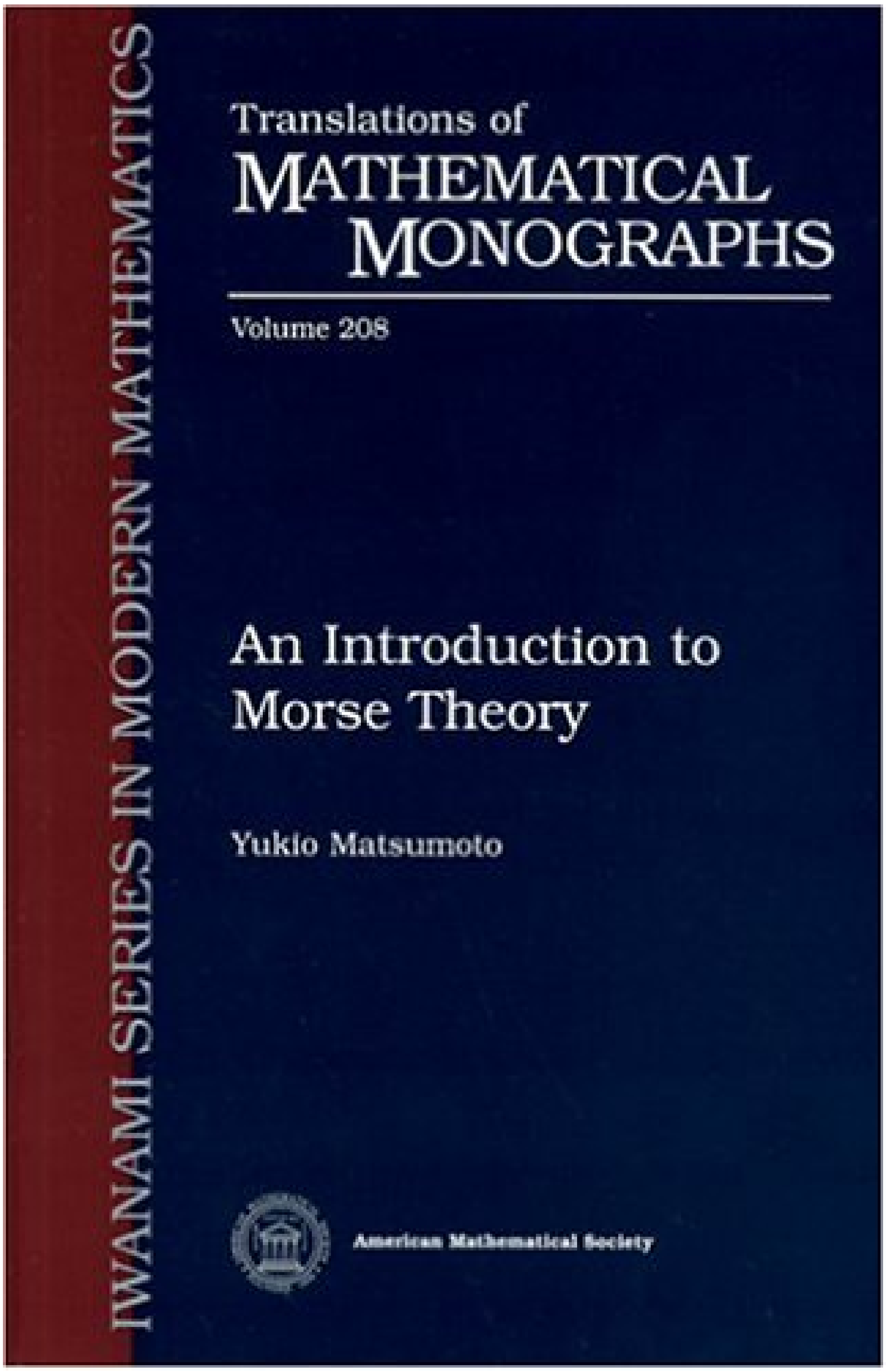
# AN INTRODUCTION TO MORSE THEORY (TRANSLATIONS OF MATHEMATICAL MONOGRAPHS, VOL. 208) BY YUKIO MATSUMOTO




IWANAMI SERIES IN MODERN MATHEMATICS
Translations of
MATHEMATICAL
MONOGRAPHS
Volume 208
An Introduction to
Morse Theory
Yukio Matsumoto
American Mathematical Society

# AN INTRODUCTION TO MORSE THEORY (TRANSLATIONS OF MATHEMATICAL MONOGRAPHS, VOL. 208) BY YUKIO MATSUMOTO PDF

As one of the window to open up the new world, this *An Introduction To Morse Theory (Translations Of Mathematical Monographs, Vol. 208) By Yukio Matsumoto* offers its incredible writing from the author. Released in among the prominent authors, this book An Introduction To Morse Theory (Translations Of Mathematical Monographs, Vol. 208) By Yukio Matsumoto turneds into one of one of the most ideal books lately. Actually, the book will certainly not matter if that An Introduction To Morse Theory (Translations Of Mathematical Monographs, Vol. 208) By Yukio Matsumoto is a best seller or not. Every publication will still give ideal sources to get the viewers all finest.

Review
"The first two-thirds of the book is accessible to anyone with knowledge of calculus in $\mathbf{R}^n$ and elementary topology. The book begins with the basic ideas of Morse theory ... on surfaces. This avoids some of the technical problems of the higher-dimensional case ... and allows a very pictorial introduction. The text, which was translated in part by Kiki Hudson, and in part by Masahico Saito, is very readable." ---- Mathematical Reviews

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In a very broad sense, "spaces" are objects of study in geometry, and "functions" are objects of study in analysis. There are, however, deep relations between functions defined on a space and the shape of the space, and the study of these relations is the main theme of Morse theory. In particular, its feature is to look at the critical points of a function, and to derive information on the shape of the space from the information about the critical points.

Morse theory deals with both finite-dimensional and infinite-dimensional spaces. In particular, it is believed that Morse theory on infinite-dimensional spaces will become more and more important in the future as mathematics advances.

This book describes Morse theory for finite dimensions. Finite-dimensional Morse theory has an advantage in that it is easier to present fundamental ideas than in infinite-dimensional Morse theory, which is theoretically more involved. Therefore, finite-dimensional Morse theory is more suitable for beginners to study.

On the other hand, finite-dimensional Morse theory has its own significance, not just as a bridge to infinite dimensions. It is an indispensable tool in the topological study of manifolds. That is, one can decompose manifolds into fundamental blocks such as cells and handles by Morse theory, and thereby compute a variety of topological invariants and discuss the shapes of manifolds. These aspects of Morse theory will continue to be a treasure in geometry for years to come.

This textbook aims at introducing Morse theory to advanced undergraduates and graduate students. It is the English translation of a book originally published in Japanese.

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11 of 11 people found the following review helpful.
Good introduction, especially for the handlebody theory
By Malcolm
Matsumoto's "Morse Theory" is one of few relatively recent treatments of finite-dimensional Morse theory, written at a level high enough to make it useful for advanced undergraduates or more likely graduate students, but with a slower pace than, say, one of Milnor's books.

Morse Theory, for the uninitiated, involves studying the behavior of functions on a smooth manifold near the critical points (of the functions) in order to deduce information about the topology of the manifold. It dates from the 1930s, but achieved its greatest results in the late '50s and early '60s with its application to the classification of manifolds via handlebody theory by Smale, Milnor, and Wallace, among others. Until now the standard treatises on the subject have been Milnor's Morse Theory and Lectures on the h-Cobordism Theorem, but the former focuses on differential geometric applications of the subject (as did Morse's classic Calculus of Variations in the Large) rather than topological ones, and the latter is OOP and hard to find. Moreover, both of these, while still relevant, are somewhat out of date, being over 40 years old and lacking any of the more recent developments in low dimensional topology, to say nothing of infinite-dimensional or complex Morse theory (which this book doesn't treat either). So certainly there is room for a new exposition of the subject, especially one geared toward students, and this one serves adequately enough.

The book begins with semi-rigorous overview of the subject in 2 dimensions using motivating examples, pictures, and explicit coordinate representations. The Morse Lemma as well as handle decompositions for 2-dim surfaces are proved modulo some results from later chapters. Concepts such as diffeomorphism are defined without a concrete definition of manifold being offered. (This is a persistent problem with this book; see below.) By restricting attention to easily visualized examples the results become intuitively obvious.

The next chapter essentially repeats the previous one, but more generally for arbitrary dimensions and more rigorously. The technical results that were assumed in the first chapter are proven here (and in the following chapter) and the precise definitions of terms are given as well. Still there is a certain amount of hand-waving when it comes to things such as smoothing of corners or flows of vector fields. Some of the definitions, such as "manifold with boundary," still lack precision, or at least, their usual generality, and some of the proofs (and definitions) in this chapter are verbatim copies of those from the first one, giving the book a disorganized feel.

The remaining 3 chapters focus on handlebody theory, and are what set this book apart from other treatments of the subject. Handlebody decompositions are demonstrated to exist for higher-dimensional smooth closed manifolds, and rules about sliding and canceling handles are established using Morse theory. (For a treatment of the subject that achieves the same results without Morse Theory see Kosinski's Differential Manifolds.) What's most interesting, and original, is a section on examples of handle decompositions that includes projective spaces and orthogonal and unitary groups.

In Chapter 4 handlebodies are related to homology, leading to proofs that manifolds are CW complexes and of (the baby version of) the Morse inequalities and of Poincare duality. Again, in this chapter, basic concepts such as CW complexes and homology are defined and reviewed, although the reader shouldn't be encountering this for the first time. The book stops well short of approaching the h-cobordism theorem; in fact, cobordisms are not even mentioned, despite the fact that a good deal of the book appears to have been lifted directly from Milnor's LHCT.

The final chapter gives an overview of low-dimensional topology via handlebody theory, first the standard classification of 2-d closed surfaces, and then analyses of 3-d manifolds using Heegaard diagrams and of 4-d manifolds using Kirby calculus. As the chapter progresses, fewer and fewer results are actually proved, until it degenerates into a list of results. Still, it's a nice introduction to this fascinating area of research and preparation for Gompf & Stipsicz's 4-Manifolds and Kirby Calculus.

As you can see from my previous comments, I have some objections to this book: Terms are often used before they are defined, or are defined only loosely. Much space is wasted discussing things that students should know already, such as the definition of a manifold or a connected sum or a statement of the maximum-value theorem. Moreover, the actual treatment of these concepts is so brief, if the reader wasn't familiar with them already this book wouldn't help, so it would be better to just use the terms without comment, as Milnor does. The details of the proofs are often less elegant than those found in, say, Milnor or Kosinski, and the proofs are often not proved in their full generality (the Morse inequalities being a striking example of this), and certain technical aspects of proofs are glossed over, such as signs in the intersection numbers that appear in the proof of Poincare duality (see Kosinski for a full treatment of this). There is also a clear sense of inadequate planning of the book, as proofs and definitions are often repeated and many theorems are proved too early, forcing a reliance upon references to later chapters.

The chapters end with a quick summary and then some exercises, all of whose solutions are given at the end of the book, which would be a bigger advantage if (a) there were more than just 3 exercises per chapter and (b) they weren't so easy. The many illustrations, so important in such a book, are a plus, as is the recommended reading list at the end of the bibliography, which includes comments on some classics in the field. There are very few errors or typos (the worst being in the definition of critical value on p. 24) and the translation from Japanese reads naturally. In fact, the text flows so easily, with minimal effort of the reader's part, that it can be read rapidly like a novel if you have prior exposure to the material, yet it is at a much higher level than, say, Wallace's Differential Topology: First Steps.

1 of 1 people found the following review helpful.
A great introduction to Morse Theory
By Gabriel Islambouli
I have now read this book cover to cover and really enjoyed it! I am a second year graduate student and the book seemed to be at about the right level for me. That being said, I feel like it can be read by an advanced undergraduate since all theorems used are clearly stated and details are always presented. In fact, my favorite thing about this book was that it was all of the details he gives in the proofs. While at times the book seems to be slogging really slowly through unnecessary details I would much rather a book err on the side of too many details.

The book covers a lot of material that will be familiar to a graduate student in topology, but from the vantage point of Morse theory. For me this vantage point was very intuitive and this book contains my favorite proof of Poincare Duality. For some reason however, Matsumoto chooses to do things like go through the definition and basic results of cohomology and the fundamental group. I feel like if you don't know these objects then this book is not a sufficient treatment whereas if you do already know these topics then these sections add nothing of value. Overall however, I found this books to be much more clear than Milnor's book which seems to be the standard book on this subject.

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