Preface

What follows thus depends upon
a combination of the methods of
the formal calculus of variations
and of Lie's theory of groups.

Emmy Noether, 1918

This book is about a fundamental text containing two theorems and their converses which established the relation between symmetries and conservation laws for variational problems. These theorems, whose importance remained obscure for decades, eventually acquired a considerable influence on the development of modern theoretical physics, and their history is related to numerous questions in physics, in mechanics and in mathematics. This text is the article "Invariante Variationsprobleme" by Emmy Noether, which was published in 1918 in the *Göttinger Nachrichten*, and of which we present an English translation in Part I of this book.

The translation of Noether's article is followed, in Part II, by a detailed analysis of its inception, as well as an account of its reception in the scientific community. As the background to Noether's research, we sketch some developments in the theory of invariants in the nineteeth century which culminated in the definition and study of differential invariants, we discuss several works in mechanics dating from the beginning of the twentieth century in which Sophus Lie's infinitesimal methods in the theory of groups began to be applied, and we show that the immediate motivation for her work was related to questions arising from Einstein's general theory of relativity of 1915. We then summarize the contents of Noether's article in modern language. In the subsequent chapters, we review the way in which Noether's contemporaries, the mathematicians Felix Klein, David Hilbert and Hermann Weyl, and the physicists Einstein and Wolfgang Pauli, acknowledged or failed to acknowledge her contribution; then we outline the quite different diffusions of her first and second theorems. Finally, we outline the genuine generalizations of Noether's results that began to appear after 1970, in the field of the calculus of variations and in the theory of integrable systems.

The present edition is based on the second edition of *Les Théorèmes de Noether. Invariance et lois de conservation au XX*^{e} *siècle* (Palaiseau: Éditions de l'École Polytechnique, 2006). For this English edition, the French text has been considerably revised and augmented, with much new information and additional references.

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