Preface

From *Problems and Solutions in Introductory Mechanics* (Draft version, August 2014)
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This problem book grew out of a "freshman physics" mechanics course taught at Harvard University during the past decade and a half. Most of the problems are from exams or problem sets, although I have added others to round out the distribution of topics. Some of the problems are standard ones, but many are off the beaten path. In the end, there is a finite number of principles in introductory mechanics, so the problems inevitably start looking familiar after a while. Two topics from the course that aren't included in this book are relativity and damped/driven oscillatory motion. Perhaps these will appear in a future edition, along with other topics such as fluids and precessional angular momentum.

This book will be helpful to both high-school students and college students taking courses in introductory physics (just mechanics, not electricity and magnetism). Calculus is used throughout the book, although it turns out that less than a sixth of the problems actually require it. This subset of problems is listed in Appendix D. If you haven't studied calculus yet, just steer clear of those problems, and you can view this book as an algebra-based one. The problems are generally on the level of the one-star or two-star problems in my *Introduction to Classical Mechanics* textbook,[1] which covers a number of more advanced topics such as Lagrangians, normal modes, gyroscopic motion, etc. I will occasionally refer you to that book if you are interested in delving further into various topics.

It is important to note that *this book should not be thought of as a textbook.* Although there is an introduction to each chapter where the basics are presented, this introduction is brief. It is no substitute for the text in a chapter in a standard introductory textbook. This book is therefore designed to be used in tandem with a normal textbook. You can think of this book as supplementing a textbook by providing a stockpile of additional problems. Or you can think of a textbook as supplementing this book by providing additional background.

In most chapters the first few problems are foundational ones. These problems cover basic results and theorems that you can use when solving other problems. When a basic result is stated in the introduction to each chapter, you will generally be referred to a foundational problem for the proof. The book is self contained, in that we derive everything we need. It's just that many of the derivations are shifted to the problems.

A set of multiple-choice questions precedes the problems in each chapter. These questions are usually conceptual ones that you can do in your head. In the rare case where they require a calculation, it is a very minor one. The book contains about 150 multiple-choice questions, in addition to nearly 250 free-response problems.

Depending on how you use this book, it can be an invaluable resource — or a complete waste of time. So here is some critical advice on using the solutions to the problems: If you are having trouble solving a problem, it is imperative that you don't look at the solution too soon. Brood over it for a while. If you do finally look at the solution, *don't* just read it through. Instead, cover it up with a piece of paper and read one line at a time until you get a hint to get started. Then set the book aside and work out the problem for real. Repeat this process as necessary. Actively solving the problem is the only way it will sink in. This piece of advice on how to use this book is so important that I'm going to repeat it and display it prominently in a box:

[1] *Introduction to Classical Mechanics, With Problems and Solutions*, David Morin, Cambridge University Press, 2008. This will be referred to as "Morin (2008)."

If you need to look at the solution to a problem to get a hint (after having thought about it for a while), cover it up with a piece of paper and read one line at a time until you can get started. Then set the book aside and work things out for real. You will learn a great deal this way. If you instead read a solution straight through without having first solved the problem, you will learn very little.

The only scenario in which you should ever read a solution straight through is where you've already solved the problem. However, even in this case you should be careful. If I've given an alternative solution, then you should again just read one line at a time until you can get started and solve it that way too.

To belabor the point, it is quite astonishing how unhelpful it is to simply read a solution instead of solving a problem. You'd *think* it would do some good, but in fact it is completely ineffective in raising your understanding to the next level. Of course, a careful reading of the introductions is necessary to get the basics down. But once that is accomplished, it's time to start solving problems. If Level 1 is understanding the basic concepts, and Level 2 is being able to *apply* those concepts, then you can read and read until the cows come home, and you'll never get past Level 1.

A few informational odds and ends: We'll use the standard mks (meter-kilogram-second) system of units in this book. Concerning notation, a dot above a letter, such as $\dot{x}$, denotes a time derivative. A boldface letter, such as $\mathbf{v}$, denotes a vector. Chapter 13 consists of appendices: Appendix A gives a review of vectors, Appendix B covers Taylor series, Appendix C is an aside on the scientific method, and Appendix D lists the problems that require calculus. There are 364 figures in the book, which coincidentally is the total number of gifts given during the 12 days of Christmas, and which ironically is one gift for every day of the year except Christmas!

It was the fall semester of 2000 when I first taught the course on which this book is based, so it would be an understatement to say that I have benefitted over the years from the input of many people, including roughly 1,000 students. I would particularly like to thank Carey Witkov for carefully reading through the entire book and offering many valuable suggestions. Other friends and colleagues whose input I am grateful for are (with my memory being skewed toward more recent years): Jacob Barandes, Allen Crockett, Howard Georgi, Doug Goodale, Theresa Morin Hall, Rob Hart, Paul Horowitz, Randy Kelley, Andrew Milewski, Prahar Mitra, Joon Pahk, Dave Patterson, Joe Peidle, Courtney Peterson, Daniel Rosenberg, Wolfgang Rueckner, Alexia Schulz, Nils Sorensen, Joe Swingle, Corri Taylor, and Rebecca Taylor.

Despite careful editing, there is zero probability that this book is error free. If anything looks amiss, please check the webpage *www.people.fas.harvard.edu/~djmorin/book.html* for a list of typos, updates, additional material, etc. And please let me know if you discover something that isn't already posted. Suggestions are always welcome. Happy problem solving!

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