Physics for Game Programmers

GRANT PALMER

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The source code for this book is available to readers at `www.apress.com` in the Downloads section.

This book is dedicated to my wonderful wife, Lisa.

Contents at a Glance

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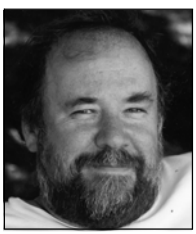
About the Author

GRANT PALMER works for the ELORET Corporation, an engineering consulting company under contract to the NASA Ames Research Center in Moffett Field, CA. Grant develops computer programs to simulate the fluid dynamics, thermodynamics, and gas chemistry of spacecraft reentering planetary atmospheres. Grant has authored or coauthored eight books on computer programming, including *Beginning C# Objects* and *Java Programmer's Reference*.

Grant lives in Bothell, WA, with his wife, Lisa, and sons, Jackson and Zachary. He has a dog, Bailey, and cat, Callie, who recently decided that she should start living in Grant's house.

About the Technical Reviewers



ALAN MCLEOD graduated from MIT with a doctorate in materials engineering, having previously gained bachelor and master's degrees in metallurgical engineering from the University of Toronto. He then worked for Alcan International as a materials scientist. After several years in industry, he decided to follow his true passion and is now teaching programming to first- and second-year engineering students as a professor and professional engineer at Queen's University and the Royal Military College in Kingston, Ontario. He also runs his own contract programming company, CA Technical Consulting.

JACK PARK gives pretty good google. To do that, he remains very active developing software in the open source arena. His projects have included NexistWiki, an experimental platform that combines topic maps, issue-based information systems, and storytelling, together with wiki behaviors and weblogs. He produced, with technical editorial help from Sam Hunting, and with authors drawn from all over the planet, the book *XML Topic Maps: Creating and Using Topic Maps for the Web* (Addison-Wesley, 2002). In a former life, he built windmills and solar heaters, and created the book *The Wind Power Book* (Cheshire-Van Nostrand, 1981). He is presently employed as a research scientist with SRI International.

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As anyone who writes a book knows, a lot of people have to work very hard to bring a book to print. I would like to thank my lead editor, Tony Davis, for always being in my corner during the writing of this book and for helping to formulate the vision for what this book would become. I would also like to thank the project manager, Laura Brown, for keeping this book on track and on schedule and for making sure that things didn't fall through the cracks. The entire production staff at Apress, Ami Knox, Kelly Winquist, and Glenn Munlawin, did a first-rate job throughout this project and always did their best to make the book the way that I wanted it to be.

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Introduction

Welcome to the wonderful world of physics. You may be thinking that "wonderful" and "physics" don't belong in the same sentence. Once you start to learn a little physics, however, you will find that it is a really interesting and rewarding subject because you will begin to gain an understanding of how things work. You will learn, for example, why a golf ball hooks or slices. You will also learn that physics really isn't as hard as you might have thought it was. Just a few basic concepts are pretty much all you need to start adding realistic physics into your game programs.

I've been a computer programmer and aerospace engineer working for NASA for the past 20 years. I really like my job, but one of the things I don't like is when I have to research the physical model for one of the programs I'm writing. Inevitably the references I find are incomplete. Either they don't fully explain things or they "forget" to include key elements of the model. Then I have to try to find another resource to fill in the missing pieces. This process can be very frustrating and time consuming.

What I have tried to do with this book is to spare you as a game programmer from this torturous process. This book is intended to give you all the information you need to install realistic physics into your game programs. This book will be *the* resource that you will turn to for all of your physics needs. For example, if you want to create a car race game, this book will give you not only the basic acceleration equations for a car, but also the drag coefficient for a sportscar and the equations that govern skidding and turning. You won't have to endlessly search the Internet or dig up another book to fill in the missing pieces.

Who This Book Is For

As you probably guessed from the title, this book is focuses on the physics needed by game programmers in order to add realism to their games. You don't need to have any background in physics to make use of this book. You don't need to have an extensive background in math for that matter either. As long as you know basic high-school-level algebra and trigonometry, you will be able to understand the physical models that are presented. This book might have been titled "Basic Physics for Game Programmers" because it focuses on the big picture. You will learn the fundamental physics concepts needed to incorporate physics-based realism into your games with the least amount of pain and suffering on your part. This book does not get bogged down in hopelessly complicated mathematical formulas that would have only a small effect on your game programs.

What This Book Is Not

This book primarily concerns itself with physics and is not a game programming book per se. There will be nothing in this book on game theory or how to render images on the screen. Many other good books on those elements of game programming are available, including *Advanced Java Game Programming* by David Croft (Apress, 2004). This book also focuses on fundamental physics and generally won't go into really advanced topics. For example, equations are presented that will let you create a realistic flight simulator, but advanced subjects like modeling the dynamic stability of an airplane in flight are not covered.

How the Book Is Divided

This book is organized into two main sections. The first six chapters will cover basic concepts, subjects like Newtonian mechanics, kinematics, and collisions. These topics will be applicable to a wide range of game programming situations. The first six chapters will provide you with the tools for your physics toolbelt. Chapters 7 through 15 take the basic concepts and apply them to specific physics models. You will learn how to model cars, planes, boats, and rockets. You will find chapters on developing sports simulations and on how to model explosions, lasers, and projectile penetrations. The later chapters will give you all the information you need to install physics-based realism into your games.

A Note on the Sample Programs

Just about every chapter contains one or more sample games that demonstrate how to code up the physics models presented in the chapter. Because this book focuses on physics, the graphics in the GUIs for the sample games are pretty basic—usually just two-dimensional figures and cartoons. While the graphics are primitive, the physics built into the sample games is real and will realistically depict whatever the game is intended to model.

Game programs can be written in many different programming languages. To keep things consistent throughout the book, the sample programs shown in this book are all written in Java, but the code that implements the physical models should be easily recognizable to anyone with a C, C++, or C# programming background. There are lots of comments throughout the programs, and the code has been made to be as readable as possible. For those of you who prefer to program in C or C#, you can download versions of all of the sample programs written in those languages from the Apress website at `www.apress.com`.

A Note on the Exercises

Many of the programs include exercises that test the reader's knowledge of the concepts that are covered in the chapter. Usually, the exercises go a little bit beyond the material that is presented in the chapter and are a good way to test your general understanding of the subject matter. The exercises were intended for students who are using this book as part of their course, but other readers are encouraged to try the exercises as well. Answers for the exercises are always provided at the end of the chapter in which they are presented.

Tidbits

Physics really is an interesting subject, and it is one that has been developing over thousands of years. The history of physics is full of many fascinating and quirky characters. Scattered throughout the book are Tidbit sections that provide historical trivia and other interesting information about the subjects being covered in the chapter. Did you ever wonder what they used to make golf balls out of in the old days? Well, there is a tidbit that will tell you.

Contact Me

If you have any questions or comments about the book, you can send me an e-mail at `grantepalmer@msn.com`. Tell me what you like about the book, or things that you think I could have done better. Also let me know if there are any subjects that you would like to see in future editions of the book.